JOURNAL OF ANIMAL SCIENCE

Volume 9

1950

JOURNAL OF ANIMAL SCIENCE

Published Quarterly

by the

American Society of Animal Production

FEBRUARY

1950

Volume 9 Number 1

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Entered as second class matter under act of March 3, 1879. The Journal of Animal Science is published during February, May, August and November, by the George Banta Publishing Co., 450–454 Ahnaip St., Menasha, Wis. Domestic subscription price is $4.00 per year; rest of North and South America $4.50; all other places $5.00. Send your subscription to the publishers, 450–454 Ahnaip St., Menasha or to Dr. H. M. Briggs, Animal Husbandry Department, Oklahoma A. & M. College, Stillwater, Oklahoma. Make check payable to the American Society of Animal Production. Foreign subscribers please remit by International money order or by a draft on a New York bank. Notices of change of address should be in the hands of Dr. Briggs 40 days previous to month of issue, to insure prompt delivery. Missing copies, owing to change in address, cannot be supplied unless adequate notice has been given.

First reprinting, 1965

Printed in the United States of America

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EFFECTS OF METHYL THIOURACIL IN THE RATIONS OF LAMBS AND AGED EWES[1]

GEORGE W. VANDER NOOT, RALPH P. REECE AND WILLIAM C. SKELLEY
New Jersey Agricultural Experiment Station

THE availability of several goitrogens has made it possible to study the role of the thyroid gland in the fattening process without resorting to surgery. Andrews *et al.* (1947) noted that thiouracil intakes of 0.175 gm. to 0.544 gm. per lamb per day had no significant effect on total gain in weight although total gain was slightly reduced in all lots receiving thiouracil. Feed requirements per pound of gain were not affected by thiouracil feeding until the intake exceeded 0.333 gm. per day. There was a tendency, however, for the gross efficiency to be reduced as the thiouracil levels were increased. Thiouracil was not relished by the lambs as it was definitely unpalatable. Willman *et al.* (1947) reported unfavorable results when thiouracil was fed to fattening lambs. Barrick *et al.* (1948) reported that the rate of gain and feed efficiency were not significantly affected by thiouracil feeding at levels of 0.18 and 0.64 gm. per lamb per day. There was a tendency for feed consumption to be reduced when 0.4 gm. or more of thiouracil was fed daily. With the availability of a new goitrogen, methyl thiouracil,[2] we became interested in its effect when fed in a ration to lambs and aged ewes to be finished for market.

Materials and Methods

In the fall of 1947, twenty-six crossbred Dorset and Hampshire lambs were divided into two groups on the basis of body weight. The control group received a basal ration that consisted of 7 parts of No. 2 yellow corn, 2 parts of bran, and 1 part of soybean meal. The grain mixture was hand-fed, allowing the lambs all they would clean up at each feeding. In the treated group methyl thiouracil was incorporated in the grain ration. On the average, the methyl thiouracil intake per lamb per day was 1.15 gm. for 9 days and 1.50 gm. for the following 32 days. Mixed hay of average quality and minerals were fed *ad libitum* throughout the trial.

A second trial was conducted with aged ewes in the fall of 1948. Fifteen ewes were placed in 3 groups on the basis of body weight. These ewes were Merino-Dorset crosses, which were nursing lambs immediately prior to the

[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station, Rutgers University, the State University of New Jersey; Departments of Animal Husbandry and Dairy Industry.

[2] The methyl thiouracil was generously supplied by the Schwarz Laboratories, Inc., Mt. Vernon, New York, through the courtesy of Dr. Earl D. Stewart.

initiation of the trial. They were maintained on pasture which was scant and in combination with milking heavily, were exceedingly low in body weight. However, their general physical condition was good, other than normal body weight. The basal grain ration was the same as that used in the first feeding trial. One group served as a control, one received the basal grain ration to which had been added 0.05 percent methyl thiouracil, and the basal ration of the remaining group contained 0.10 percent methyl thiouracil. The grain ration was hand-fed, the ewes being allowed all they would readily consume at each feeding. Mixed hay of average quality and minerals were fed *ad libitum* throughout the trial, the duration of which was 30 days.

In each trial individual weights were recorded at the beginning and end of the experiment. These data were treated statistically by the method of analysis of variance as outlined by Snedecor (1946). Thyroid glands were removed from some of the animals and weighed.

TABLE 1. EFFECTS OF METHYL THIOURACIL ON WEIGHT GAINS AND FEED CONSUMPTION OF FATTENING LAMBS (41 DAYS)

Group	No. of animals	Avg. initial weight	Avg. gain in weight	Avg. daily gain	Concentrates consumed per 100 lbs. gain**
		lbs.	lbs.	lbs.	lbs.
Control	13	76.0	13.1	0.32	573
Methyl thiouracil*	13	76.3	9.8	0.24	645

* Methyl thiouracil fed at the rate of 1.15 grams per day for 9 days and 1.50 grams per day thereafter.
** Hay and minerals *ad libitum*.

Results and Discussion

Influence of methyl thiouracil on weight gains and feed consumption of fattening lambs

The inclusion of methyl thiouracil in the grain ration of fattening lambs resulted in less rapid gains than those observed in lambs on a goitrogen-free ration. The experimental lambs gained, on the average, 0.24 of a pound per day while the control lambs gained 0.32 of a pound per day. Although the control lambs consumed more grain than did the experimental lambs, nevertheless they required less feed per unit of gain than did the lambs receiving methyl thiouracil. The control lambs required 573 pounds of grain per 100 pounds of gain while the experimental lambs required 645 pounds (table 1). The differences in weight gains were not statistically significant. The average weight of the thyroid gland of 3 control lambs was 2.3 gm. whereas that of 3 experimental lambs was 20.8 gm.

Effect of feeding 0.05 and 0.10 percent methyl thiouracil to aged ewes

Five aged ewes fed the basal grain ration showed an average daily gain of 0.41 of a pound. Ewes fed a grain ration containing 0.05 percent of methyl thiouracil gained, on the average, 0.59 of a pound per day; those receiving 0.10 percent methyl thiouracil in the grain ration gained 0.37 of a pound per day. The differences in weight gains were not statistically significant.

The concentrates consumed per 100 pounds were not greatly different for the control group and the group receiving 0.10 percent methyl thiouracil 568 and 538 pounds respectively. The group of ewes that received 0.05 percent methyl thiouracil, however, required 25 percent less feed per unit of gain than did the control group (table 2). The thyroid gland of one control ewe weighed 4.6 gm.; the glands from 4 ewes receiving 0.05 percent methyl

TABLE 2. EFFECTS OF METHYL THIOURACIL ON WEIGHT GAINS AND FEED CONSUMPTION OF AGED EWES (30 DAYS)

Group	No. of animals	Avg. initial weight	Avg. gain in weight	Avg. daily gain	Concentrates consumed per 100 lbs. gain*
		lbs.	lbs.	lbs.	lbs.
Control	5	75.4	12.4	0.41	568
Methyl thiouracil 0.05%	5	77.0	17.6	0.59	425
Methyl thiouracil 0.10%	5	76.0	11.0	0.37	538

* Hay and minerals *ad libitum*.

thiouracil averaged 11.0 gm.; and 4 glands from ewes fed a grain ration containing 0.10 percent methyl thiouracil averaged 13.1 gm.

One of the limiting factors in the use of goitrogens in sheep has been the lack of palatability. In this work the grain ration containing the methyl thiouracil appeared to be eaten readily by both lambs and ewes. Nevertheless, with the exception of the ewes fed at a 0.05 percent level, the amount of grain concentrate consumed per animal per day was less for the experimental animals than it was for the controls. This lessened grain consumption could be attributed to either a lack of palatability for which there was no visual evidence, or to the lowered metabolic rate. If the results on the ewe experiment can be taken as an indication of optimum methyl thiouracil levels then it is obvious that the lambs received an excessive amount of the goitrogen. The daily intake of methyl thiouracil of the ewes on the 0.05 percent level was 0.56 of a gram whereas the average daily intake of the lambs was 1.42 gm. It does not follow, however, that a lowered goitrogen intake would

be advantageous in the ration of fattening lambs. Goitrogens are advantageous in the ration of swine during the finishing period, but not in the ration of weanling pigs (Vander Noot, Reece, and Skelley, 1948).

Summary

Thirteen lambs fed an average of 1.42 grams of methyl thiouracil daily for 41 days showed an average daily gain of 0.24 of a pound and consumed 645 pounds of grain per 100 pounds gain. Thirteen control lambs gained 0.32 of a pound per day and consumed 573 pounds of grain per 100 pounds gain.

The average daily gain of 3 groups of 5 ewes each was: control, 0.41; 0.05 percent thiouracil, 0.59, and 0.10 percent thiouracil, 0.37. The group of ewes receiving 0.05 percent methyl thiouracil required 25 percent less feed per unit of gain than did the control group. There was no advantage in feeding ewes a grain ration containing 0.10 percent methyl thiouracil.

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THE VALUE OF REFUSE SCREENINGS AS A FEED FOR LIVESTOCK[1]

G. W. Scott, Jr., T. H. Blosser, A. O. Shaw and U. S. Ashworth
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REFUSE screenings are used rather widely as a feed for livestock, especially in areas where small grains are grown. Refuse screenings are a combination of materials obtained in the process of cleaning grain such as light or broken grain seed, weed seed, hulls, chaff, joints, straw, elevator dust and floor sweepings. The question arises as to whether or not a feed of such composition has much value as a source of concentrates for livestock.

Refuse screenings also have been found to be a means of spreading noxious, unpalatable, and poisonous weed seeds.

This experiment was conducted in order to learn something of the chemical composition, total digestible nutrient (TDN) content, and apparent digestibility of the refuse screenings beeing sold in the State of Washington. Also to determine the numbers and kinds of viable weed seeds present in the screenings and the numbers and kinds of weed seeds still viable after being subjected to the process of digestion.

McCulloch (1940) has demonstrated that the seeds of the yellow burweed or yellow tarweed, *Amsinckia intermedia*, a weed seed fairly common to screenings in certain areas, are toxic to horses, swine, and cattle. According to Morrison (1948) screenings containing many mustard seed are very unpalatable to stock. Richardson and Deckson (1936) found that lambs fed on wheat screenings produced a soft, flabby, lean carcass with a scant covering of fat of greasy texture which was definitely less desirable in flavor than that of the wheat fed lambs.

In the Montana trials of Tretsven and Nelson (1946) dairy cows ate concentrate mixtures which contained ten percent wild mustard and eight percent fanweed. The milk yield was as high as that of cows receiving a ration containing no weed seed and the flavor of the milk was not harmed.

According to Morrison (1948) the best grades of screenings resemble oats in composition and may nearly equal grain in feeding value. However, some of the poor quality screenings more nearly resemble straw in composition and feeding value.

[1] Published as Scienific Paper No. 845, Agricultural Experiment Station, Institute of Agricultural Sciences, State College of Washington, Pullman.

[2] Division of Dairy Husbandry. The authors are grateful to the Department of Animal Husbandry for furnishing the ewes and metabolism cages used in this experiment and to Dr. R. W. Colby of that department for his assistance and helpful suggestions. Further acknowledgment is made to Dr. L. W. Rasmussen and Miss Mary Haferkamp of the Agronomy Department who conducted the germination studies.

Crampton and Whiting (1943) conducted a digestion trial on swine using Canadian standard recleaned wheat screenings which weighed 50 pounds per bushel and consisted of 60 percent broken wheat and 40 percent wild buckwheat. They obtained a TDN value of 63.

Schneider (1947) reports a TDN content of 65.2 (wet basis) for wheat screenings using sheep and goats as the test animals.

Atkeson *et al.* (1934) found that the digestion processes of cattle greatly reduce the percent of viable weed seeds. This tended to minimize manure as a source of weed infestation. Storage of the manure for three months caused an additional reduction in viability. When feeds containing large numbers of viable seed, especially of some plants, were fed, the resulting manure was a possible weed menace. Lambsquarter was figured to be the most resistant and it was still 22 percent germinable after the manure had been stored for three months.

Harman and Keim (1934) recovered an average of 14.2 percent uninjured weed seeds from calves, horses, sheep, hogs, and chickens. An average of 6.7 percent viable seeds was recovered from each 1,000 seeds fed to these animals. After being stored in manure for three months, all seeds were dead except bindweed which germinated only one percent.

Experimental

Three ewes weighing approximately 180 pounds each were used as test animals in this trial. The sheep were kept in metabolism cages designed to collect the feces quantitatively separate from the urine. In order to eliminate weigh-backs and reduce experimental error, only that amount of feed which the sheep would consume was fed.

The following order of feeding was followed:

Period	*Purpose*	*Kind of feed consumed*
First	Transition	Chopped Alfalfa
Second	Feces collection	Chopped Alfalfa
Third	Transition	55% chopped alfalfa, 45% refuse screenings
Fourth	Feces collection	55% chopped alfalfa, 45% refuse screenings
Fifth	Transition	Refuse screenings
Sixth	Feces collection	Refuse screenings

All periods were 10 days in length. The alfalfa was chopped into lengths of $\frac{1}{2}$ to $\frac{3}{4}$ inches and the refuse screenings were ground with a hammer mill using a $\frac{3}{8}$ inch screen. The entire batch of alfalfa was thoroughly mixed after chopping and a representative sample was taken for analyses. The refuse screenings were likewise mixed and sampled.

Accurate records of feed intake were kept during the periods feces were being collected. Each animal received approximately two grams of salt daily and water *ad libitum*.

Feces were removed from the metabolism cages twice daily and stored at 0° F. in 50 pound cans. At the completion of each ten day collection period the cans of feces were removed from cold storage, allowed to come to room temperature and weighed. All of the feces collected from each sheep during each ten day collection period were thoroughly mixed after being weighed and a representative sample, of approximately 200 grams, was taken from each for analyses. All samples were then dried and moisture was determined. These samples were then ground, and analyzed for crude fiber, crude protein, ether extract and ash using the methods given by A.O.A.C. (1945). Nitrogen free extract was determined by difference. The samples of alfalfa and refuse screenings were also analyzed in a like manner.

The Washington State College seed laboratory conducted germination tests and seed counts on the ground refuse screenings. Germination tests were also run on the manure resulting from the ingestion of the ground screenings by the sheep.

Results and Discussion

Table 1 shows the chemical composition of the alfalfa hay and refuse screenings used in this trial.

TABLE 1. CHEMICAL COMPOSITION OF HAY AND REFUSE SCREENINGS

Feed	Sample No.	Gross analyses—100% dry basis					
		Dry matter	Ash	Ether extract	Crude protein	Crude fiber	Nitrogen free extract
		%	%	%	%	%	%
Refuse screenings	1381	90.4	9.6	7.3	16.0	17.2	49.9
Chopped alfalfa	1382	92.0	8.2	1.9	13.3	38.2	38.4

The coefficients of apparent digestibility of the alfalfa hay, refuse screenings when fed with the hay, and refuse screenings when fed a'one are shown in table 2. The coefficients on screenings were calculated two ways n order to check on the accuracy of the work and also to learn what effect the hay had upon the digestibiltiy of the refuse screenings.

The total digestible nutrient content of the alfalfa hay, refuse screenings when fed with the alfalfa, and refuse screenings when fed alone is given in table 3. The average TDN content of refuse screenings when fed with alfalfa was 61.6 a scompared with a value of 58.4 when the screen ngs were fed alone.

TABLE 2. MEAN APPARENT DIGESTIBILITY OF ALFALFA HAY, REFUSE SCREENINGS WHEN FED WITH HAY, REFUSE SCREENINGS WHEN FED ALONE

Ration	Apparent digestibility				
	Dry matter %	Ether extract %	Crude protein %	Crude fiber %	NFE %
Alfalfa hay	51.9±0.93*	20.8±2.28	68.3±0.78	35.0±3.13	68.0±0.50
Alfalfa hay and refuse screenings	57.1±0.79	77.9±1.91	73.3±1.77	47.4±8.95	71.2±0.82
Refuse screenings	60.2±1.90	71.3±5.12	69.3±1.75	31.6±3.44	72.9±1.38

* This figure in each case represents standard error of the mean.

TABLE 3. TDN CONTENT OF ALFALFA HAY AND REFUSE SCREENINGS WHEN FED WITH THE ALFALFA AND WHEN FED ALONE—(WET BASES)

Sheep No.	Alfalfa hay	Refuse screenings with alfalfa	Refuse screenings alone
4	44.5	64.2	55.6
12	47.0	57.3	62.3
22	45.0	63.4	57.2
Mean	45.0	61.6	58.4

TABLE 4. WEED SEEDS PRESENT IN THE REFUSE SCREENINGS AFTER GRINDING ON ⅛ INCH SCREEN

Name of weed	Approximate number of seeds per pound
Noxious:	
Fanweed	9,534
Others:	
Lambsquarter	44,492
Russian Thistle	1,359
Fiddleneck	453
Mustard Species	453
Wild Oats	453
Grass Species	906
Jim Hill Mustard	453
Green Fox Tail	906
Chickweed	906

The approximate number of weed seeds present per pound of ground refuse screenings is given in table 4.

After the ground refuse screenings were subjected to the processes of digestion germination studies showed none of them to be viable.

Discussion

Different samples of refuse screenings vary widely in chemical composition and feeding value. Morrison (1948) has pointed out that a good grade of screenings may closely approach oats in feeding value while a poor grade more nearly resembles wheat straw. On the basis of TDN content the refuse screenings used in this experiment fell about midway between oat straw and the small grains.

Refuse screenings had a higher TDN content (61.6) when fed with hay than when fed alone (58.4). This could be explained on the basis of the supplemental action of the two feeds.

No weed seeds were found to be viable in the manure voided on a diet of finely ground refuse screenings. This is not quite in agreement with the work of Atkeson *et al.* (1934) who found some seeds still viable in cow manure after the manure was stored for three months. The discrepancy between our findings and those of Atkeson *et al.* is quite logically explained since they fed whole weed seeds to cows, while in our experiment the screenings were ground and fed to sheep.

Summary

1. A study has been made of the chemical composition, apparent digestibility, and TDN content of refuse screenings.

2. Studies were also conducted on the numbers and kinds of weed seeds present in the ground refuse screenings and the viability of these seeds both before and after being subjected to the process of digestion.

3. The chemical composition of the refuse screenings studied was: dry matter, 90.4%; ash, 8.7%; ether extract, 6.8%; crude protein, 14.5%; crude fiber, 15.6%; and nitrogen-free extract, 45.1%.

4. The refuse screenings had a TDN content of 58.4 when fed alone and 61.6 when fed with alfalfa hay.

5. Feces voided on a diet of refuse screenings alone contained no viable weed seeds.

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THE INFLUENCE OF RATE OF FREEZING AND LENGTH OF FREEZER-STORAGE UPON THE QUALITY OF BEEF OF KNOWN ORIGIN[1]

A. M. Pearson[2] and J. I. Miller
Cornell University

RECENT evidence indicates that beef improves in tenderness when frozen without aging or after only short periods of aging (Hankins and Hiner, 1940 and 1941; Hiner *et al.*, 1945; Blakeslee and Miller, 1948). Furthermore, the tenderizing action due to freezing was reported to be greater with rapid than with slow freezing. Whether or not the same relationship holds true for beef having different degrees of finish has not been studied.

In spite of the fact that rapid freezing has been generally advocated for meat, recent studies with fruits and vegetables (Diehl and Berry, 1933; Lee *et al.*, 1946) indicate that the rate of freezing has little influence on the quality of the frozen product. Although rapid freezing appears to tenderize beef, the over-all effects of the different rates of freezing have not been determined. Furthermore, the relative importance of rate of freezing and length of freezer-storage upon the quality of beef needs further clarification.

Experimental Procedure and Results

Experiment I

The object of this study was to compare the effects of rate of freezing and length of freezer-storage upon the quality of beef fattened on grass alone (Lot IV), full-fed corn on pasture (Lot II), or finished in dry lot at the end of the pasture season (Lot V).

Three representative steers from each lot of ten steers were slaughtered, and the carcasses were aged for six days. After aging, the longissimus dorsi muscles were stripped out of the wholesale ribs from each carcass and cut into ten pairs of steaks, approximately 1½ inches in thickness. Each pair consisted of opposite right and left steaks. The steaks from each steer were divided into three groups of three pairs of steaks each, which left one pair to be used as unfrozen controls. One group of steaks from each steer was frozen at the slow rate (approximately 20 hours to reach 20° F.); another group was frozen at the intermediate rate (approximately five hours); and the remaining

[1] A portion of a thesis submitted to A. M. Pearson to the Graduate School, Cornell University, Ithaca, New York, in partial fulfillment of the degree of Doctor of Philosophy.

[2] A. M. Pearson is now in the Department of Animal Husbandry, University of Florida, Gainesville, Florida.

group was frozen at the rapid rate (approximately one hour). The rate of freezing was determined with a thermocouple attached to a potentiometer. Figure 1 shows representative freezing curves determined in this study.

The steaks were stored at 0° F. for either 0, 90, or 180 days. Removal from freezer-storage was according to plan, so that one pair of steaks frozen by each method was removed at the end of each storage period.

Color of frozen lean, drip, expressible fluid, percentage of water, total weight losses (all losses from fresh unfrozen condition to cooked steak), tenderness, cooking losses and palatability were used as the criteria for

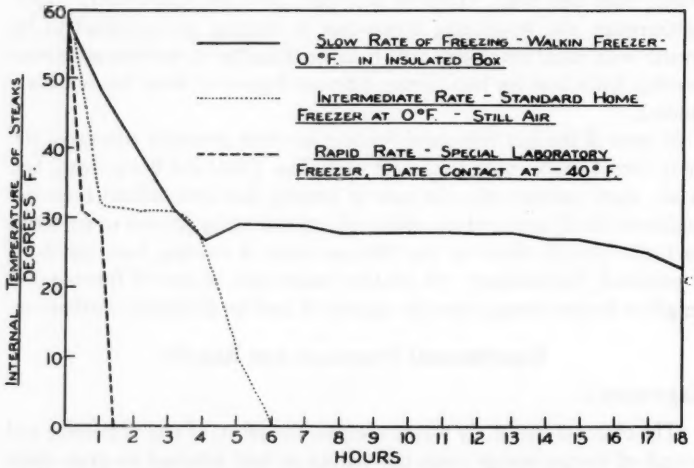
SLOW RATE OF FREEZING - WALKIN FREEZER - 0 °F. IN INSULATED BOX
INTERMEDIATE RATE - STANDARD HOME FREEZER AT 0°F. - STILL AIR
RAPID RATE - SPECIAL LABORATORY FREEZER, PLATE CONTACT AT -40° F.
INTERNAL TEMPERATURE OF STEAKS DEGREES F.
HOURS
0
10
20
30
40
50
60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Figure 1. Freezing curves for steak frozen at three different rates obtained with thermocouples attached to a potentiometer.

quality. Drip was determined by difference in weight between the frozen and thawed condition and was expressed as percentage loss. In this study the steaks were thawed for 18 to 20 hours in a large cooler, which fluctuated from 32° to 34° F., and as a result, thawing was incomplete. Tenderness was measured with the Warner-Bratzler shear, using the average of three 1-inch cores from each cooked (internal temperature 150° F.) steak. Palatability was determined by a qualified panel of judges on roasts and steaks, in which the rate of freezing was the only variable. Carcass yields were calculated and the animals were graded, both on foot and in the carcass. In order to determine the influence of ration upon firmness of body fat, the iodine number of fat obtained over the 10th and 11th ribs was measured by the Hanus Method as outlined by the A.O.A.C. (1935).

TABLE 1. EFFECT OF METHOD OF FINISHING, RATE OF FREEZING AND LENGTH OF FREEZER-STORAGE UPON BEEF

Items compared	Lot II. Corn on pasture	Lot IV. Pasture only	Lot V. Pasture then dry lot	Rate of freezing			Length of storage		
				Slow	Medium	Rapid	0 days	90 days	180 days
Grade on foot[1]	4.3	9.0**	4.7						
Carcass grade[1]	5.0	8.7**	5.0						
Dressing percentage[2]	58.9	52.3**	59.2						
Iodine number of fat	49.13	49.65	50.34						
Palatability[3]				5.4	5.5	5.6			
Color of lean[4]	5.7	6.7	5.7	8.6	7.0**	3.0**			
Drip in percent	1.87	0.90	0.74	1.04	1.12	1.33			
Cooking losses in percent	24.04*	26.33	26.57	24.83	26.30	25.81	23.31**	27.06	26.72
Total weight losses in percent	25.49	27.18	27.48	25.95	27.37	26.82	24.27**	28.40	28.54
Moisture content of lean muscle in percent	75.08*	75.59	73.91**	75.01	74.77	74.79	75.20	75.46	75.05
Tenderness in lbs. to shear a 1-inch core	14.8	17.3**	14.4	15.3	16.3	14.9	14.5**	17.5	17.5
Expressible fluid in ml./100 g. of ground meat	37.58	37.46	37.36	37.00	37.69	37.71	36.71*	38.33	39.47

* Significant.

** Highly Significant.

[1] Grade on foot and carcass numerical grades are based on the following numbers:

Top Choice —1	Top Good —4	Top Medium —7	Top Common —10
Average Choice—2	Average Good—5	Average Medium—8	Average Common—11
Low Choice —3	Low Good —6	Low Medium —9	Low Common —12

[2] Dressing percentage was calculated on the basis of 3 percent shrink from live weight, full feed, and a 2½ percent shrink on warm dressed weight.

[3] The mean score for palatability was the average of scores for appearance, juiciness, tenderness, flavor of lean, flavor of fat, texture and aroma. Possible values range from 7 to 1, with 7 being excellent and 1 being inedible.

[4] The color readings shown for different lots of beef were made before freezing, while all other values were obtained after freezing. Munsell beef color paddles having the following values for fresh lean beef were used for determining the values.

1–4, bright; 5–6, shady; 7–8, dark; 9–10, black.

The results of the feeding trial have been summarized by Miller *et al.* (1947), while the results of this study are presented in table 1.

As is shown in table 1, the steers finished on pasture alone (Lot IV) had a lower carcass yield, a higher percentage of moisture in the lean muscle, and graded lower, both on foot and in the carcass, than steers from either of the other two lots, which were full-fed in dry lot (Lot V) or on pasture (Lot II). However, there was no difference between steers from the various lots in regard to firmness of external fat or color of lean. On the other hand, the animals finished on pasture alone produced steaks which were less tender than those from either of the other two lots.

The rate of freezing did not appear to influence cooking losses, total weight losses, expressible fluid, moisture content, tenderness or palatability. However, the color of the frozen lean became progressively lighter as the rate of freezing was increased.

As the length of freezer-storage was increased from 0 to 90 days, there was a highly significant increase in cooking losses, total weight losses and expressible fluid. Steaks tested at 0 days were measurably more tender than those stored for 90 days. However, no further change in tenderness could be detected as the storage period was increased from 90 to 180 days.

While the percentage of drip did not appear to be influenced by rate of freezing or length of freezer-storage in this study, subsequent experiments showed that drip increased during storage but failed to show up in this experiment due to incomplete thawing.

Experiment II

This study was undertaken to ascertain the effects of rate of freezing and length of freezer-storage upon drip, cooking losses, total weight losses and tenderness. In this experiment, the method of measuring drip losses was altered to allow complete thawing at room temperature. Tenderness was determined as in Experiment I, except that five ½-inch cores were removed from each steak instead of three 1-inch cores as were used in the previous study.

The steaks used in this study were obtained from ten Hereford steers approximately 18 months of age, which had been fattened in dry lot. All carcasses graded average good with the exception of the one from steer H, which graded average choice. After holding each carcass at 32° F. for six days following slaughter, the wholesale rib and the adjacent six inches of short loin were removed from the right side of each carcass. The longissimus dorsi was removed and cut into 13 steaks as was described in Experiment I.

In this study a total of 120 steaks representing ten different steers were frozen at one of the three rates of freezing used in Experiment I, and held in

storage at 0° F. for either 0, 60, 120, or 180 days. Each steak was then thawed, cooked and analyzed for drip, cooking losses, total losses and tenderness. In addition, one steak from each steer was analyzed in the fresh condition and used as a basis of comparison. The results of this experiment are summarized in tables 2 and 3.

With no freezer-storage, the rate of freezing had no measurable influence upon drip losses, although the variation in amount of drip between different steers was highly significant. Conversely, no detectable difference in cooking

TABLE 2. SUMMARY OF STATISTICAL ANALYSIS FOR EXPERIMENT II. MEAN SQUARES

Source of variation	Degrees of freedom	Tenderness	Drip losses	Cooking losses	Total weight losses
Total	119				
Steers	9	5.473**	40.06**	14.56	46.370**
Rate of Freezing	2	1.050	15.10**	6.42	3.935
Period of Storage	3	3.867**	102.12**	130.85**	236.246**
Storage×Rate of Freezing	6	0.825*	2.89	6.13	7.863
Steers×Rate of Freezing	18	0.354	10.13**	5.85	8.637
Steers×Storage	27	1.042**	6.56**	12.67	13.297
Error Term	54	0.356	1.27	9.00	9.310

* Corresponding F value was statistically significant.
** Corresponding F value was highly significant.

losses could be assigned to variations between steers, or to different rates of freezing. Although the unfrozen control steaks had significantly lower total losses than any of the frozen steaks, the differences between rates of freezing and between steaks from individual steers were not significant. Even though there were no differences in tenderness which could be assigned to variations in the rates of freezing, the differences in tenderness between steaks from various steers were highly significant.

At 0 days' storage the drip losses, cooking losses and total losses were measurably lower than at any of the longer periods of storage. The increase in drip during freezer-storage is in agreement with the results of Ramsbottom and Koonz (1941). Furthermore, there was a decrease in tenderness after 60 days' storage. which is in agreement with the results obtained in Experiment I.

Although marked variations were observed to exist between steers in respect to drip, total losses and tenderness, the differences could not be explained by variations in finish or breeding. Moreover, the significance of the interaction of length of storage with both rates of freezing and steers indicates the variability in response to the same treatment.

TABLE 3. SUMMARY OF THE EFFECTS OF RATE OF FREEZING AND LENGTH OF FREEZER-STORAGE UPON BEEF

Items compared	Drip losses, percent	Cooking losses, percent	Total weight losses, percent	Tenderness in lbs. to shear a ½ inch core
		Means for Steers (all values)		
Steers:				
A	9.13**	25.32	33.53**	5.73**
B	7.78	24.54	31.47	4.82
C	5.10	23.59	29.14	5.12
D	4.17	24.28	28.49	4.87
E	6.14	25.10	30.39	4.30
F	8.40	26.37	32.66	5.02
G	5.94	22.74	28.95	5.10
H	5.14	23.04	29.29	3.81
I	3.38**	23.83	28.74	3.71**
J	3.72	23.87	27.88**	3.88
LSD at 5% level[1]	0.92	n.s.	2.50	0.49
LSD at 1% level[1]	1.32	n.s.	3.34	0.65
		Means for Rates of Freezing		
Rates:				
Slow	5.19**	24.65	29.80	4.80
Medium	6.14	23.85	29.94	4.64
Rapid	6.34**	24.31	30.40	4.47
LSD at 5% level[1]	0.51	n.s.	n.s.	n.s.
LSD at 1% level[1]	0.67	n.s.	n.s.	n.s.
		Means for Length of Freezer-Storage		
Lengths:				
0 days	3.14**	21.67**	26.08**	4.39**
60 days	6.84	24.80	30.09	4.39**
120 days	7.09**	26.29**	32.34**	4.60
180 days	6.49	24.65	31.68	5.15**
LSD at 5% level[1]	0.58	1.56	1.58	0.33
LSD at 1% level[1]	0.80	2.07	2.11	0.44

** Highly significant—only extremes are so designated.

[1] The least significant difference is given at both the 5 and 1 percent levels. Where the differences are not significant, it is indicated by the symbol n.s.

Although the rate of freezing did not appear to affect either cooking losses or total losses, there seemed to be a trend for the faster rates of freezing to give a slightly, though not significantly, more tender product.

Summary and Conclusions

Two experiments are reported in which 282 steaks cut from 19 different steer carcasses were frozen at either a slow, intermediate, or rapid rate and held for varying storage periods at 0° F. An additional 28 steaks were analyzed in the fresh condition as controls.

Steers full-fed corn, either on pasture or in dry lot, yielded higher dressing percentages, graded higher, both on foot and in the carcass, and yielded steaks which were lower in moisture and were more tender than steaks from similar steers fattened on grass alone. Since there was little difference in tenderness or general desirability of beef produced by steers full-fed grain, either on pasture or in dry lot, the degree of fatness rather than the nature of the pasture accounts for the differences observed.

The rates of freezing used in this study did not measurably alter cooking losses, total weight losses, expressible fluid, tenderness or palatability. However, the color of lean became progressively lighter as the rate of freezing was increased from slow to rapid.

Freezer-storage resulted in a marked increase in cooking losses, total weight losses, drip and expressible fluid, which became apparent at the end of 90 days of storage. Similarly, freezer-storage resulted in a decrease in tenderness. Thus, this study indicates that rapid freezing does not improve the over-all quality of beef, and that freezer-storage resulted in a measurable deterioration in quality.

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COMPARATIVE DIGESTIBILITIES BY STEERS OF RATIONS CONTAINING DISTILLERS DARK GRAINS FROM MALT AND FROM FUNGAL AMYLASE FERMENTATIONS[1]

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THE development of new feeds and of methods of processing them carries with it the question of whether or not the nutritional qualities of the product have been altered. The investigation reported herein was designed to compare the digestibilities by steers of rations containing distillers dark grains from malt and from fungal amylase fermentation.

La Mense *et al.* (1947) found that high amylase-producing strains of *Aspergillus niger* such as NRRL 337 could be readily grown on a medium composed of thin stillage supplemented with 2% of corn meal and 0.5% or calcium carbonate. After incubation under continuous aeration for 3 to 5 days, culture liquors were satisfactory replacements for distiller's malt in the alcoholic fermentation of corn.

When conventional distillery equipment was utilized, Le Mense *et al.* (1949) reported that saccharification was satisfactory and alcohol yields were comparable to those obtained with malt when mold culture liquor equivalent to 6 to 10% of the final mash volume was used. A more economic alcohol production may be realized and a "cleaner" alcohol fermentation results from the use of mold amylase in lieu of malt as the converting agent.

Using the favorable experimental results obtained with fungal amylase fermentation as a criterion it seems feasible for fungal enzymes to substitute for malt in the distilling industry.

Experimental

Six two-year-old grade Hereford steers were used in conducting the digestion trials. They had been used previously for similar investigations at this station so were not appreciably disturbed by the experimental procedure.

The ration consisted of eleven pounds of concentrate mixture (92.5% corn and 7.4% Dark Grains), two pounds of hay and two pounds of straw. The rations were similar in all respects with the exception of Dark Grains. Dark Grains from malt fermentation were used in Ration I and those from fungal amylase fermentation were used in Ration II. The dark grains from malt

[1] Data used in this paper were taken from a thesis submitted by the senior author in partial fulfillment of the requirements for the degree of Master of Science in Agriculture.

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fermentation were produced from a 90% corn, 10% barley malt mash bill. Those from fungal amylase fermentation were produced from a mash in proportions of 56 pounds of corn and 3.6 gallons of mold-amylase liquor and were from the first large scale run of fungal amylase fermentation of the Grain Processing Company of Muscatine, Iowa. The former dark grains were somewhat lighter in color than the latter and were not so uniform in consistency since they contained residues from the barley hulls.

The chemical analysis of the ration ingredients and mixed rations is shown in table 1.

TABLE 1. COMPOSITION OF FEEDSTUFFS (AS ANALYZED)

	H_2O	Protein	Ether extract	Crude fiber	N.F.E.	Ash
Dark Grains (malt)	6.4	25.3	11.8	6.2	45.9	4.8
Dark Grains (F.A.)	5.5	25.6	13.3	6.0	45.8	4.3
Corn	11.7	8.4	4.1	1.4	72.6	1.9
Hay	10.7	6.4	2.5	29.6	46.0	4.8
Straw	6.1	2.7	1.6	49.4	35.9	4.3
Ration I	10.5	8.3	4.0	11.8	62.7	2.8
Ration II	10.4	8.3	4.1	11.8	62.7	2.8

Two digestion trials were conducted. During the first, steers 4, 5 and 6 were fed Ration I, and steers 1, 2 and 3 received Ration II. This arrangement was reversed for the second trial. Each trial consisted of a ten day preliminary period followed by an eight day collection. Feed and water were provided twice daily.

Feces were collected by use of the Garrigus-Rusk (1939) bag. A representative sample of the daily feces was placed in a water-proof plastic bag and kept in a freezing locker until the end of the trial, at which time the daily aliquots from each steer were thawed and mixed thoroughly. Duplicate samples were then placed in a drying oven for moisture determination and further laboratory analysis. A sample was also taken at the time of mixing to be used for protein determination on the fresh basis.

Laboratory analyses of feeds and feces were made by methods adopted by the Association of Official Agricultural Chemists including specific procedures for the determination of moisture and fat in Distillers Dark Grains.

Results and Discussion

The average coefficients of apparent digestibility and their standard deviations are presented in table 2.

There is no significant difference between the coefficients of apparent

digestibility of the two rations. This indicates that the fermentation process by which Distillers Dark Grains are produced does not affect their digestibility to an extent measurable in this type of experimentation.

Of the total protein present in each ration the dark grains contributed about 16.5%. Thus, if the protein digestibility of the ration were to be reduced by 5 percentage units due to a reduction of the digestibility of protein in the distillers dark grains, this latter digestibility would have to be reduced by more than 30%. Although we have not obtained a critical

TABLE 2. AVERAGE COEFFICIENTS OF APPARENT DIGESTIBILITY AND THEIR STANDARD DEVIATIONS

Nutrient	Ration I	Ration II
Dry Matter	67.4±1.02	66.4±1.34
Protein	48.7± .96	48.3±2.92
Ether Extract	67.5±3.11	69.6±4.41
Crude Fiber	41.8±2.26	41.8±6.23
N.F.E.	75.8±1.85	74.3±2.28

measure of the digestibility of the dark grains themselves, we have obtained data indicating their relative effect as parts of similar rations, uncomplicated by sources of error inherent in methods of determining digestibility "by difference."

Summary

Digestion trials were conducted with steers to compare the digestibility of a ration containing distillers dark grains from malt fermentation with one containing distillers dark grains from fungal amylase fermentation. The rations fed were identical except for the difference in source of dark grains.

No significant difference was found in the apparent digestibility of these rations, thus indicating that the two processes of fermentation do not differ significantly in their effects upon the digestibility of distillers dark grains.

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THE RELATION OF THE CAROTENE CONTENT OF RANGE FORAGE TO THE VITAMIN A REQUIREMENT OF BREEDING COWS[1]

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IN RECENT years data have been secured by many investigators on the carotene content of various livestock feeds and forages, along with suggested adequate carotene intakes. Recent attention is being focused on the vitamin A requirements of beef cattle with determinations of carotene and vitamin A being made on the blood or blood plasma. More data are available for dairy cattle than for the beef breeds. Guilbert and Rochford (1942) state that during the last months of gestation a 1000 pound beef cow requires about 75 milligrams of carotene. This is five times the amount needed for maintenance. Riggs (1940), from results on 260 range cattle varying in ages from 3 to 16 months, found the depletion time to range between 2 to 9 months on a ration practically devoid of carotene. Davis and Madsen (1941) present blood plasma and vitamin A data for Hereford and Shorthorn cattle on various levels of carotene intakes which range from severe shortages and abnormal calves to large surpluses and normal calves. The results of Payne and Kingman (1947) show that the carotene blood-plasma level of first calf range Hereford heifers must be at least 117.75 ± 7.21 and that aged cows must be at least 82.88 ± 4.17 micrograms per 100 ml. for adequate health and reproduction.

Experimental work published at this station by Watkins (1943) shows that the carotene content of the range grasses appeared to be generally sufficient for lactating range cows four years out of five. The present project was planned to investigate the blood carotene and vitamin A levels of these breeding cows at 28-days intervals to detect periods of the year when range cows may suffer from lack of carotene.

Experimental Procedure

In this project thirty-two grade Hereford cows, reared on the experimental range were used during the first 24 periods. For the balance of the project or for 37 periods 16 cows were weighed and bled at each 28-day interval.

[1] Published with the approval of the Director of the New Mexico Agricultural Experiment Station. Contribution No. 55.

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These cattle were fed a mixture of equal amounts of salt and bone meal to correct a phosphorus deficiency known to exist on this range. No other supplements were fed during the project. The pasture was stocked at about 66 percent of capacity to insure the continuance of the project through any but the most severe drouth periods.

The pasture used is typical of a large part of southern New Mexico and Arizona and southwest Texas. The principal grasses are black grama (Bouteloua eriopoda), and mesa dropseed (Sporobolus flexuosus) with minor amounts of tobosa grass (Hilaria mutica), three-awn grass (Aristida spp.) and burrograss (Scleropogon brevifolius). The browse plants consist of mesquite (Prosopis spp.) and yucca (Yucca elata). Cattle utilize the foliage of these plants very little, but they do consume the blooms and seed pods of

TABLE 1. SAMPLING DATA FOR MAY 20, 1947

Forage	Pasture	Field wt. harvested, grams	Weight of sample,* grams	Carotene,* mg. per 1000 gms.	Weighted average carotene,* mg. per 1000 gms.
Three awn grass	14	9	8.8	47.52	
Weeds and Annual Plants	14	44	3.15	64.97	28.38
Black Grama	14	10	9.9	23.11	
Yucca elata blooms	14	70	57.4	6.24	

* Calculated on a 95% dry matter basis.

both species. Palatable annuals grow rather abundantly over the area in favorable fall and spring seasons.

Samples of forage were taken at 28-day intervals throughout the experiment. Twenty plots were located in the pasture so as to represent each major vegetative type and all parts of the pasture. A plot ten feet square was staked at each location and left open to grazing. A fenced plot of equal size was so placed that the vegetation in the two plots correspond as closely as possible. When samples were taken, at least ten plants of each species present were measured in both protected and open plots. If the measurements showed that some of the grass had been grazed in the open plot, an equal amount and kind of forage was harvested from the protected plot. The measurement of the height of the forage in the protected and in the open plots has given a pattern of what grasses were being grazed during the various seasons of the year. Sampling annual weeds and browse was more difficult. If the cows were observed grazing some of these plants a sample was taken. If it was estimated that such plants constituted approximately 20% of the ration, one-fifth of the total forage samples collected on that date

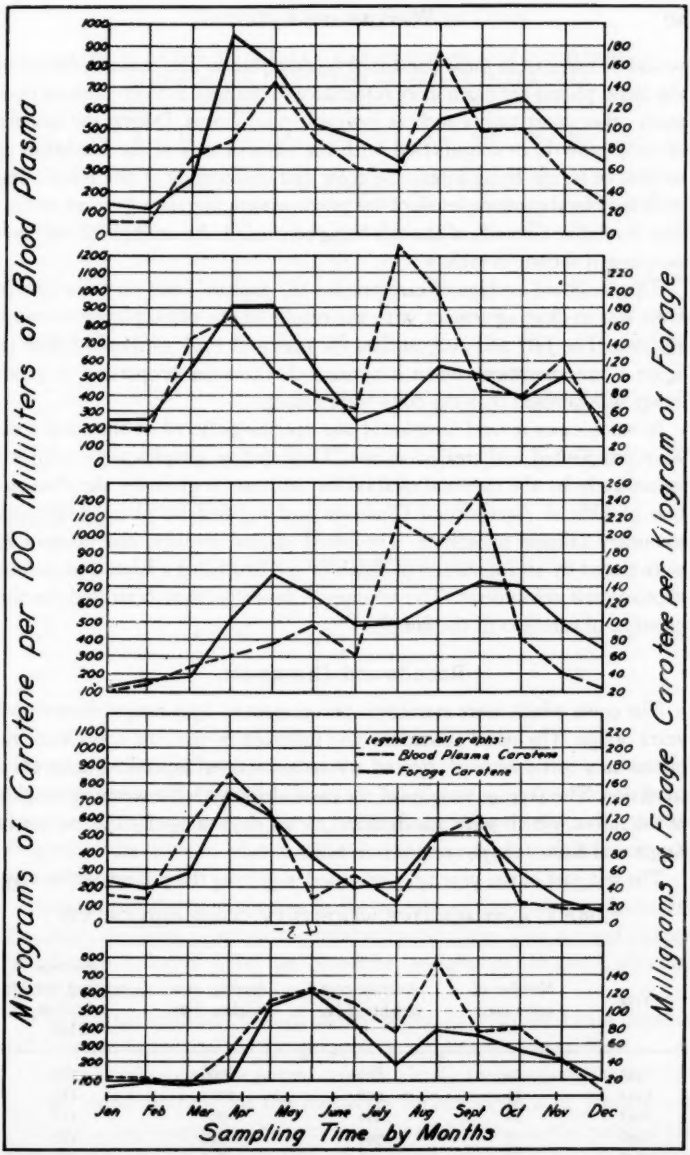

Figure 1. The average blood plasma carotene of range Hereford cows as compared to the forage carotene. Blood plasma carotene for 1944 and 1945 represents averages of 32 cows, while for the last three years, the averages were for 16 cows.

would be taken from these annuals or browse plants. The carotene values of the blood plasma are much more responsive to changes in food carotene than many other constituents such as inorganic phosphorus. During the months of early growth, in conjunction with the observations of the herdsman as to kind of forage being eaten, the color and consistency of the feces along with the blood carotene levels of the previous sampling date gave an indication of relative amounts of annuals being consumed. An example of one such sampling is shown in table 1.

The weighted average of carotene for the pasture with very few exceptions was in close agreement with the results of the blood plasma carotene analyses. The July and August data for 1945 and 1946, as shown below in figure 1, are exceptions when it appears that a larger proportion of green forage was sampled than the cows were eating.

In some cases several samples of one species gathered at the same time were composited and treated as one. These forage samples were analyzed immediately by the chemical method for carotene as given by the Association of Official Agricultural Chemists and purified by filtering through secondary calcium phosphate. The blood plasma corotene and vitamin A were tested by an adaptation of Kimbles' method using a Klett-Summerson photoelectric colorimeter. The vitamin A readings were corrected for the presence of carotene in the sample.

Results and Discussion

The cows which were started on this project in 1943 ranged from 6 to 8 years of age. The usual procedure was followed in that the cows were replaced at 9 to 10 years of age and sometimes sooner depending upon their condition. The average weights of the cows along with the weaning weights of the calves, which were standardized to 205 days of age by the method of Koger and Knox (1945), are given in table 2.

The last part of the year 1943 was used in getting the project under way.

TABLE 2. AVERAGE LIVE WEIGHTS OF COWS AND CALVES

Year	Number of cows used	Average cow weights, May	Average cow weights, Nov.	Average weaning weights of calves, Nov.
1943	32	819	996	387
1944	32	996	1011	456
1945	32	970	935	417
1946	15	945	949	475
1947	15	936	895	472
1948	14	877	903	408

TABLE 3. AVERAGE PLASMA CAROTENE, PLASMA VITAMIN A, AND FORAGE CAROTENE BY 28-DAY INTERVALS

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	13th period
Average Blood Carotene in Micrograms Per 100 Millimeters of Plasma													
1944	144	120	260	958	800	524	459	330	546	596	641	439	330
1945	246	243	557	912	922	545	248	336	571	517	373	505	244
1946	134	162	176	517	773	653	482	498	622	738	704	491	347
1947	234	196	271	750	610	376	200	228	512	529	296	124	66
1948	66	98	64	83	534	612	437	187	382	360	270	204	98
Average	165	163	265	644	727	542	365	315	526	548	457	353	217
Average Vitamin A in Micrograms per 100 Millimeters of Plasma													
1944	40	48	44	67	57	58	63	47	69	57	64	60	54
1945	45	47	53	59	60	63	50	54	57	59	53	60	50
1946	46	50	45	64	63	68	61	62	59	62	60	61	52
1947	50	46	54	63	60	56	50	44	60	66	51	46	43
1948	41	47	43	28	59	57	47	48	55	44	48	48	49
Average	44	47	47	56	59	60	54	51	60	58	55	55	50
Average Forage Carotene in Mg. Per Kilogram of Feed on 95 Percent													
1944	16	16	73	87	144	93	61	57	174	97	100	55	28
1945	42	39	145	173	108	79	62	249	197	84	79	123	34
1946	21	27	48	62	75	95	60	220	187	253	81	42	25
1947	30	28	109	173	124	28	54	26	100	125	27	18	15
1948	22	21	17	50	110	124	111	75	158	77	80	41	9
Average	26	26	78	109	112	83	69	125	163	127	73	56	22

It was unfortunate, however, that the project was not being conducted at that time since in the spring of 1943 the range was very dry with very few early green plants or annuals. This poor feed condition is reflected in the low weights of the cows in May and also in the low weights of their calves at weaning time.

During 1947 the precipitation in the months of September and October was light, resulting in very little production of grass. This seemed to have considerable influence upon the November weights of the cows, although the calf weights were above average.

The average analyses for each 28-day period of both the blood carotene and Vitamin A and also the forage carotene are presented in table 3.

The approximate yearly pattern can be clearly seen from the table. The average blood carotene for the five years for the months of January and February is approximately 165 micrograms, which is the lowest point of the year. This level is much more than adequate when compared to the requirements of lactating cows, which, according to various workers, need from 82

to 118 micrograms in the blood. The blood carotene levels rise quite rapidly during the last of March and reach a peak during April and May which is higher than is recorded for the months of July, August and September which is the usual growing season for the native grasses. This high carotene of the blood during March, April and May is due to the presence of palatable annuals which, as has been mentioned before, appear during spring seasons having favorable moisture conditions. These annuals consist of various species of mustards and other palatable weeds. An inspection of the forage carotene in the last part of table 2 also portrays high carotene values for these same months. The blood carotene during the mid-summer is moderately high with the expected higher values occurring during the growing season of the late summer and fall.

Low blood carotene was recorded for December, January, February and March of 1947–1948, which was very close to and sometimes lower than the amounts usually considered necessary for pregnant or lactating cows.

Although the mean minimum temperature averaged 4.8° F. below and the precipitation was 58 percent of normal, the grasses contained approximately the same amount of carotene as is usually found between the months of October and January inclusive. It is believed that the extreme cold and dry conditions of the earlier part of the winter prevented and retarded the growth of fall weeds and annuals which are usually present in this area of Southern New Mexico.

Kemmerer and co-workers (1942) suggest a possible lower utilization of carotene in dried grasses and state that a carotene content of not less than 4 parts per million (36 mg. in 20 pounds of feed) may be needed. It is possible that a lower utilization of the carotene in the partially dormant grasses along with the scarcity of the usual green plants during the winter months of 1947–1948 may account for the lower blood carotene values. This period of low carotene lasted about four and one-half months but was followed in April by appearance of green plants and quite high blood plasma carotene. Thus the only threat of a carotene or Vitamin A deficiency during the project did not materialize. Symptoms of Vitamin A deficiency were not observed among the cows during this period.

At these levels of carotene intake, the vitamin A content of the blood seems to fluctuate very little. There are higher Vitamin A values when accompanied by high blood carotene values. The correlation coefficient between the blood carotene and the Vitamin A was .81. The standard deviations for the Vitamin A and for the carotene of the blood were 7 and 140 respectively.

The forage carotene given for each period represents an attempt to arrive at the carotene value of the forage which the cows were eating during that

period. The sampling at one of the spring periods may contain several samples of grass, a sample of annuals or green weeds, and a portion of immature yucca blooms. In figure 1, the forage carotene is compared to the blood carotene of that period.

The average forage carotene and the average blood plasma values for each period when plotted agree quite closely. The correlation coefficient of these two sets of data is .63. The forage carotene during July and August of 1945 and 1946 was relatively higher than the blood values for those periods. However, it is surprising that the two sets of data agree as closely as they do in in view of the difficulties of accurately sampling range pastures of rather large dimensions.

The pattern by periods show the forage carotene to be lowest during the first part of January and February, but to rise sharply in March and continue high until the last part of December.

Summary

The blood carotene, Vitamin A and forage carotene values have been presented for Hereford breeding cows grazing on a typical Southern New Mexico range and covers an interval of four and one-half years. The blood carotene of these cows when compared to existing statements of requirements seems to indicate that a Vitamin A deficiency might occur only in case of prolonged drouth or extremely abnormal conditions. This type of range produces certain plants which usually remain green throughout the fall, winter and spring seasons; these plants seem to have assisted, along with some of the grasses, in providing carotene to meet the requirements of these beef cows.

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THE EFFECT OF SALT, PEPPER AND SAGE ON THE STABILITY OF GROUND PORK STORED AT ZERO DEGREES FAHRENHEIT

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A PART of almost every hog slaughtered is used for pork sausage. A large amount of this sausage is stored in frozen food lockers. All stored pork products are subject to oxidative rancidity regardless of the methods of processing and storage. If the sausage remains in storage for three to six months, the development of rancidity is almost certain to affect its palatability. Beadle (1946) stated that rancidity in fat not only renders food unpalatable, but can also be responsible for the partial destruction of the essential fatty acids, and of other dietary nutrients, such as vitamins A and E, perhaps D, and certain members of the B complex.

The object of this investigation was to determine the influence of all combinations of salt, pepper, and sage, common sausage seasoning agents, on the stability of the fat in the sausage.

Dubois and Tressler (1943) showed that the stability of both beef and pork products was affected adversely by the use of salt, but pepper, sage, mace, and ginger seemed to have an antioxidant effect. Graf (1946) found that sausage prepared without salt keeps better than the same product prepared with salt. At the end of three months, sausage containing salt had deteriorated in appearance, flavor, and odor. Samples to which sugar, sage, and pepper had been added were slightly more acceptable and had lower deterioration values after nine months storage than the samples to which no seasoning had been added. Lea (1934) found that salt occurring in curing pickle for bacon had a pronounced accelerating effect on the oxidation of pork fat. Lea (1939) found that sodium chloride in solutions buffered at various pH values, or in solutions containing enzyme-free extracts of tissue, failed appreciably to accelerate oxidation. He concluded that salt has no direct effect on the rate of oxidation of lard. In earlier work, Lea (1934) had shown a marked accelerating effect of salt on oxidation of extracted pork fat, but later he concluded that this test was confounded by traces of copper and iron.

Lea (1939) isolated an enzyme he called lipoxidase from pork muscle juice which accelerated the oxidation of pork fat. He found that this effect could be destroyed by heating the extracted juice, or increased by adding sodium chloride. A similar enzyme was found in the adipose tissue.

Ziels (1945) found that all metals tested except aluminum and nickel exerted some catalytic pro-oxidative effect on various oils. He suggested the formation of a metallic soap by the interaction of the metal and the free fatty acid.

Experimental Procedure

One hog large enough to supply the necessary ground pork was selected from the herd of the Animal Husbandry Department of the Agricultural and Mechanical College of Texas. This hog was slaughtered and chilled for about twenty-four hours at thirty-six degrees Fahrenheit.

After chilling, the carcass was cut, and suitable portions were selected to give a hundred pounds of ground pork containing about 60 percent lean. Analysis by suitable methods (1945) showed a percentage composition of 16.9 protein, 38.5 fat, and 44.3 moisture.

This meat was divided into eight equal portions and treated with salt, pepper, and sage as follows: A—no seasoning; B—sage only; C—pepper only; D—sage and pepper; E—salt only; F—salt and sage; G—salt and pepper; H—salt, pepper and sage.

The factorial experimental design was selected because of the complete information it yields, and because the interpretation of the information obtained is usually clear after it has been subjected to an analysis of variance.

Commercial flake salt was used at the rate of 2 percent by weight, Dalmation rubbed sage at the rate of 0.375 percent, and Griffith's black pepper at the rate of 0.25 percent. These agents were sterilized in an autoclave before use.

After seasoning, the meat was ground in a meat grinder through the three-fourths inch plate followed by the three-sixteenths inch plate. Grinding twice gave even distribution of fat and lean and even dispersion of the seasonings. The grinder was washed thoroughly after the meat from each portion had been ground to prevent confounding the following treatment by a residue of the previous one remaining in the grinder.

Eighty samples weighing about forty grams each were taken from each treatment. These samples were labeled and arranged in four large, flat, galvanized iron pans, twenty samples from each treatment to each pan. These pans were placed on top of a row of lockers in the storage room. A beaverboard shield about eight inches above the pans protected the samples from falling snow, but no other protection was used. The samples were not wrapped. Quick freezing was accomplished by eighteen hours storage in the sharp freezer at twenty degrees below zero Fahrenheit.

The samples were of uniform shape and size as each was molded with an ice cream dipper. This was considered essential because rancidity develop-

ment begins on the surface and proceeds toward the center. Lea (1939) stated that the area surface exposed per gram has a pronounced effect on the rate of oxidation of a sample.

The first test was made after two months storage time had elapsed. Subsequent tests were made biweekly until rancidity or marked reversion was evident in all treatments. This required fourteen tests. Each test yielded thirty-two peroxide values, as four replicates from each treatment were analyzed.

The samples containing sage only and sage plus pepper could not be described as rancid on December 14, 1946, the date of the fourteenth determination, but a flavor change had occurred, and it was concluded that the effect of the seasonings alone and in combination had been demonstrated adequately, so the test was terminated.

Methods of Determining Rancidity

This investigation was designed to determine the effects of seasoning on rancidity development by using peroxide numbers as criteria of rancidity. The peroxide values were determined by the method developed by Wheeler (1932). These values did not give all the information desired, and some organoleptic tests were made for supplementary information. The quantitative Kreis test as developed by Watts and Major (1946) was used immediately after its publication, but the values obtained correlated highly with peroxide values on the same samples. This high correlation showed that the Kreis test gave little or no additional information, and its use was discontinued.

Results

The mean peroxide values obtained for the eight treatments on each of fourteen dates are shown in figure 1.

The increasing peroxide values of the unseasoned sample (A) were expected. All samples containing sage (B, D, F, & H) had lower peroxide values than the unseasoned sample, with little, if any, increase in values over the six month period. The sample with pepper only (C) behaved about like those containing sage alone and in combination with other ingredients. Commercial salt alone (E) gave markedly higher peroxide values than any other treatment. Where pepper (G) was added, a definite depressing effect was noted, and sage with salt (F) gave lower values than unseasoned pork (A). It must be concluded that salt promotes rancidity in frozen ground pork stored at zero degrees Fahrenheit, and that sage has a marked antioxidant effect, while pepper seems to have only a slight antioxidant effect. These results are in agreement with the findings of Dubois and Tressler

(1943) and Graf (1946). In this investigation, there was no synergistic effect resulting from the combination of pepper and sage judging from peroxide values obtained.

Organoleptic tests for rancidity do not always agree with peroxide indications, so checks by organoleptic means are desirable. On June 22, the date of the second peroxide determination, the sample containing salt and

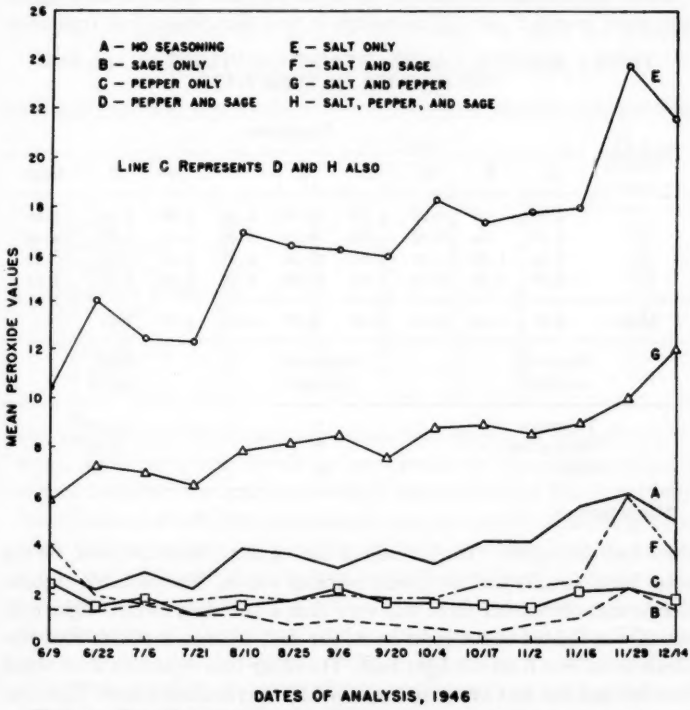

Figure 1. The effect of seasoning agents and time in storage on peroxide values of frozen ground pork.

pepper (G) was slightly rancid. All others were free from organoleptic rancidity.

Analysis of variance was made on the peroxide values determined at each date. The results shown for the values in table 1 for the determination on November 16 are typical of the findings at other dates.

At the first determination, the treatments were significantly different. Earlier peroxide determinations should have been made so that the first

treatment effects could have been recorded. Previous work by Dubois and Tressler (1946) had not indicated such an early effect of treatment as found in this test.

The replications proved to be significantly different on August 25, and their differences were significant at each date thereafter. This was not expected, but the consistently significant differences in replications indicated a causative environmental factor. When the peroxide values for each replication were averaged over all treatments it was then found that replication

TABLE 1. PEROXIDE VALUES OBTAINED NOVEMBER 16, 1946 AND THE ANALYSIS OF THESE DATA

Replicates	Treatments								
	A	B	C	D	E	F	G	H	Mean
I	4.72	.92	2.08	1.56	17.52	2.32	9.26	3.39	5.22
II	5.76	.84	2.06	.82	15.31	1.07	9.11	1.76	4.59
III	6.34	1.59	2.71	2.66	20.22	4.57	9.45	2.83	6.30
IV	5.66	1.64	2.07	1.29	17.60	2.56	8.58	4.10	5.44
Mean	5.62	1.25	2.23	1.58	17.66	2.63	9.10	3.02	

Source of variation	Degrees of freedom	Mean square
Treatment	7	125.30**
Replications	3	3.97**
Error	21	.66

** Highly Significant.

three had the highest value in each of the 14 tests. Replicate four, on the other hand, usually had the lowest peroxide values. The probable explanation is that replication three was very near a 100 watt electric light bulb which was lighted about eight hours per day, whereas replicate four was about seven feet from the light bulb. The other two replicates were about two feet and five feet away, and usually had intermediate values. This is in keeping with the findings of Coe and LeClerc (1933), who reported that light promoted rancidity.

After peroxide values were obtained on November 16, the remainder of each sample was broiled and submitted to a panel of four food experts for organoleptic testing. The experts had no knowledge of the treatments involved. They were asked to state that the sample was rancid or was not rancid. Results of this test are shown in table 2.

By comparison of tables 1 and 2, it can be seen that peroxide values do not correlate well with organoleptic tests. Mean peroxide values for treatments

C and D were not statistically different, while the judges were unanimous in their opinions that C was rancid and D not rancid. While H was rather high in peroxide value, three out of four judges declared it was not rancid. Probably it could be described as reverted.

This comparison shows that peroxide values alone may give misleading results, and almost certainly do not correlate highly enough with true rancidity to be used in ranking samples with respect to rancidity.

This fact became evident after the experiment was about half complete,

TABLE 2. RESULTS OF ORGANOLEPTIC TEST
NOVEMBER 16, 1946

Treatment		Judge				Mean peroxide values
		1	2	3	4	
Salt only	(E)	R	R	R	R	17.66
Salt and Pepper	(G)	R	R	R	R	9.10
No Seasoning	(A)	R	R	R	R	5.62
Salt, pepper & sage	(H)	N	N	N	R	3.02
Salt and sage	(F)	N	R	R	R	2.63
Pepper only	(C)	R	R	R	R	2.23
Pepper and sage	(D)	N	N	N	N	1.58
Sage only	(B)	N	N	N	N	1.25

and another method of assigning values was sought. A chemical method which measured quantitatively an end-product in rancidity development seemed essential. The quantitative Kreis test as given by Watts and Major (1946) seemed to fulfill the requirements, as it presumably measures quantitatively the concentration of epihydrin aldehyde, which has been shown to be an end-product in rancidity development by Powick (1923) and others. This test was run in addition to the peroxide test and organoleptic tests for the determinations on November 16 and 29, using the same samples. The Kreis values obtained for the determination on November 16, when compared with peroxide values, had a correlation coefficient of +.9655, and for the determination on November 29 the correlation coefficient was +.9667. These high correlation values indicated that the peroxide method was as efficient as the quantitative Kreis test in determining rancidity.

Summary and Conclusions

Commercial salt speeds the oxidation of frozen ground pork.

Salt in the presence of pepper is not as active in promoting rancidity as salt alone, but the inhibitory action of pepper on salt is limited.

Completely seasoned sausage containing 2 percent salt, .375 percent sage,

and .25 percent black pepper remained stable longer than unseasoned ground pork.

Salt in the presence of sage had some pro-oxidant activity, but much less than when acting alone or in combination with pepper.

Black pepper has rather weak antioxidant properties.

Sage has decided antioxidant properties.

No synergistic effect was noted as a result of the combination of sage and pepper.

Light produced by an incandescent bulb of 100 watts seemed to have a pro-oxidant effect.

Results obtained from the same samples by the peroxide test and the quantitative Kreis test correlated highly.

A method of assigning numerical deterioration values to fats which will correlate highly with organoleptic estimation is still needed.

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RELATIONSHIP BETWEEN CERTAIN BODY MEASUREMENTS AND CARCASS CHARACTERISTICS IN SWINE

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EXTENSIVE studies have been reported on the relationship of such factors as type, conformation, and degree of finish to carcass quality in swine. Few attempts, however, have been made to determine the value of individually recorded body measurements for predicting the quality and quantity of a hog carcass. The acquisition of such information might be of considerable practical importance, particularly in the case of animals which vary but little on the basis of visual appearance. Such information might also have an important effect in a breeding program where improvement of carcass quality is a major objective.

Ferrin (1939) reported that hogs measuring from 46 to 48 inches in body length and from 29 to 31 inches in carcass length produced a higher proportion of desirable carcasses when slaughtered at 225 pounds live weight than hogs above 48 inches in body length or above 31 inches in carcass length. Bogart, Weaver, and Comfort (1940), studying the carcass yields of 69 Poland China hogs in their relation to the scores and measurements for various characteristics in the live animals, found that both scores and measurements were of little value for predicting the yields of ham, loin, shoulder, or belly. The same authors (1940a), working with 127 Poland China hogs, reported significant correlations between carcass score as determined by visual inspection of eight carcass items and the scores for certain items in the live animals. However, live-hog score for grade was found to be the only item of practical value for estimating carcass score. Phillips, Hetzer, and Hiner (1939) obtained highly significant correlations between the scores for various characteristics in a group of 145 market hogs and the yields of several different cuts of their carcasses. None of the correlations, however were large enough to be very important from the practical standpoint.

The purpose of this study was to determine the relative value of various live-hog measurements for predicting certain characteristics of the carcasses produced. The characteristics studied were: (1) the combined yield of ham, loin, bacon, picnic shoulder, and shoulder butt, and (2) the yield of lean meat in the ham. The combined yield of the five cuts was chosen because they represent the most valuable cuts of a hog carcass, constituting about

[1] The authors wish to acknowledge the assistance of R. L. Hiner in supervising the cutting of the carcasses and the physical analysis of the hams.

75 percent of the market value of a hog. The yield of lean meat in the ham, on the other hand, was chosen because of its high predictive value of the amount of lean meat in the entire dressed carcass (Hankins and Hiner, 1937).

Materials and Methods

The data studied came from 141 hogs fed in Record of Performance trials at the Agricultural Research Center, Beltsville, Md., in the fall of 1947. The 141 hogs, 71 barrows and 70 gilts, came from 70 litters sired by 6 boars. They consisted of representatives of the Landrace-Chester White, Landrace-Duroc, Landrace-Duroc-Hampshire, Yorkshire-Duroc-Landrace-Hampshire, Landrace-Large Black, and Landrace-Poland China strains being developed at Beltsville and of representatives from the 30 possible crosses between the six strains. Each hog was removed from the feeding trial at a live weight of approximately 225 pounds and was kept without feed for 24 hours before slaughter. Prior to slaughter, measurements were obtained on each hog for each of eight items; namely, (a) length from ear to tail, (b) height at shoulders (c) width at shoulders, (d) width of middle, (e) width at hams, (f) depth at chest, (g) depth of middle, and (h) circumference at chest. Each of these measurements was taken twice on the same hog by each of two men, except the circumference measurement which was obtained only once by each man. All measurements taken on a hog were obtained on the same day, usually within a two-hour period. The measurements were taken according to the methods described by Phillips and Dawson (1936).

The average slaughter weight of the 141 hogs was 211 pounds, the individual weights ranging between 190 and 224 pounds. Slaughtering and cutting were done according to the procedures described by Hankins and Hiner (1937). After chilling for 72 hours, each carcass was separated into a full-cut head, short-cut unskinned hams, and two-rib picnic shoulders with shoulder butts and plates removed. The middle piece was separated into rough loin and rough belly just ventral to the tenderloin muscle. About $\frac{1}{4}$ inch of back fat was left on the loin. The belly was trimmed just above the teat line and the brisket, back, and flank ends were merely squared. The yield of lean meat in the hams was determined by separating the lean from the other parts of the right ham of each hog and multiplying the amount of lean meat by two. After each cut was weighed both the combined yield of hams, loins, bacons, picnic shoulders and shoulder butts and the yield of lean meat in the hams were converted into percentages based on live weight at slaughter.

Analysis of the data was made according to methods described by Lush and Molln (1938). The general form of the analyses used to determine the relative accuracy of the various body measurements studied is the same

as that used by Lush (1938) in his study of the repeatability of scores in pigs.

The means of the various items studied are shown in table 1. There was practically no difference between barrows and gilts for any of the items except for width of middle, yield of the five cuts, and yield of lean meat in the hams. The gilts averaged about 0.8 cm. less in width of middle and yielded about 1.0 percent more in the five cuts and about 0.72 percent more

TABLE 1. MEANS OF LIVE-HOG MEASUREMENTS AND WEIGHTS, AND OF CARCASS YIELDS FOR EACH OF THE TWO SEXES

Items measured, slaughter weights, and carcass yields	Barrows		Gilts	
	Mean	Standard deviation	Mean	Standard deviation
Live-hog measurements[a]				
Length ear to tail (cm.)	106.8	2.97	107.3	2.70
Height at shoulders (cm.)	57.7	1.83	58.2	1.55
Width at shoulders (cm.)	35.5	1.03	35.5	1.12
Width of middle (cm.)	33.8	1.43	33.0	1.40
Width at hams (cm.)	33.6	.96	33.3	.91
Depth at chest (cm.)	40.2	.94	40.3	.91
Depth of middle (cm.)	44.7	1.27	45.0	1.43
Circumference at chest (cm.)	109.3	2.21	109.0	2.61
Slaughter weight (lbs.)	210.6	4.48	211.2	5. 8
Carcass yields[b]				
Yield of five cuts (%)	48.5	1.54	49.5	1.67
Yield of lean meat in hams (%)	8.24	.80	8.96	.82

[a] All live-hog measurements are based on averages of four measurements for each pig except the circumference measurement, which is based on two readings.

[b] Based on live weight at slaughter.

lean meat in the hams than the barrows. The differences for these items are in each case highly significant and conform to the findings of Warner, Ellis, and Howe (1934) that barrows fatten more rapidly than gilts. Analyses of the inter-relationships between the various items were accordingly made for each sex separately.

Results and Discussion

Accuracy of body measurements

Since a pig's position changes so frequently, body measurements such as those studied might not be very reliable. As a first step to determine the relative accuracy of the various measurements, the correlation or repeatability of single measurements on the same hog was calculated for each measure-

ment. An example of the method used is given in table 2, which shows the analysis of variance in body length for the 141 hogs which were measured twice by each of the two men. The repeatability between single measurements of body length was 0.724, or 72.4 percent. This figure is to be compared with the residual variance (27.6 percent) which is due to errors of measurement, including differences in the measurements of the two men. Although this latter value is only about one third as large as the former, it is large enough to suggest that a substantial gain in precision might be obtained

TABLE 2. ANALYSIS OF VARIANCE IN BODY LENGTH FOR THE 141 PIGS WHICH WERE EACH MEASURED TWICE BY EACH OF TWO MEN

Source of variation	Degrees of freedom	Mean squares	Composition of mean squares	
Men	1	64.41*	A+2C+141D+282G	G= 0.23
Times	1	8.59	A+2B+141D+282F	F= 0.04
Pigs	140	33.24*	A+2B+2C+4E	E= 7.85
Men×Times	1	0.06	A+141D	D=−0.03
Men×Pigs	140	4.14	A+2C	C= 0.23
Times×Pigs	140	1.36	A+2B	B=−1.16
Men×Times×Pigs	140	3.68	A	A= 3.68
Total	563	10.68		

A = variance due to interaction between men, times, and pigs.
B = variance due to interaction between times and pigs.
C = variance due to interaction between men and pigs.
D = variance due to interaction between men and times.
E = variance due to differences between pigs.
F = variance due to differences in time of measurement.
G = variance due to differences between measurements of the two men.

$$\text{Repeatability between single measurements on the same pig} = \frac{E}{A+B+C+D+E+F+G} = 0.724.$$

* Highly significant at the .01 level.

by averaging several measurements. To check this point, use was made of the formula $\frac{nr}{1+(n-1)r}$, as given by Lush (1943), in which r is the correlation between single measurements and n is the number of measurements taken. Table 3 shows the repeatability figures for the various body measurements based both on single measurements and on the average of four measurements as determined by this formula.

As shown in table 3, the repeatability between single measurements on the same pig ranged from 0.558 for height at shoulders to 0.767 for width of middle, the values for the other items lying between these two extremes. It is clear from inspection of the variance components in table 3 that the

relative accuracy of the various measurements was largely a function of the interaction components and that differences between the measurements of the two men as well as time differences were too small in most cases to be of any importance.

As was to be expected, the repeatabilities between the averages of four measurements were higher in all cases than those based on single measurements. It will be seen, moreover, that the lower the repeatability between single measurements, the greater was the increase in accuracy resulting from averaging four measurements. This is not surprising, however, since the

TABLE 3. VARIANCE COMPONENTS AND REPEATABILITY ESTIMATES FOR THE EIGHT BODY MEASUREMENTS

Items	Variance components[1]							Repeatability	
	G	F	E	D	C	B	A	Single measurement	Average of four measurements
Length ear to tail	.23**	.04	7.85**	−.03	.23	−1.16	3.68	.724	.913
Height at shoulders	.30**	.10**	2.64**	−.00	.46*	− .86	2.12	.558	.834
Width at shoulders	.01**	−.01	1.18**	.02	−.10	− .46	1.03	.702	.904
Width of middle	.04**	−.00	1.99**	.00	.18	.07	.31	.767	.929
Width at hams	.00	.01*	.77**	−.00	−.02	− .05	.55	.608	.861
Depth at chest	−.00	−.00	.71**	.00	.08	.03	.44	.561	.836
Depth of middle	.03*	.01	1.54**	−.01	.22	− .06	.81	.607	.861
Circumference at chest[2]	.43	—	4.63**	—	—	—	2.50	.649	.881

*=Statistically significant at .05 level.

**=Highly significant at .01 level.

[1] See Table 2 for meaning of symbols.

[2] Circumference at chest was measured only once by each man; hence there are no estimates for the variance associated with B, C, D, or F.

amount of error which is removed by averaging several measurements would naturally be expected to decrease as the accuracy of individual measurements increases. At any rate, the increases in accuracy resulting from several measurements appear to be large enough in all cases to justify obtaining more than one measurement where such practice is feasible. For the purpose of this study it was decided, therefore, to use as many measurements as were obtained for each hog.

Relation of body measurements to yield of five cuts

Table 4 shows the simple correlation coefficients between the various body measurements, with each other and with the yield of the five cuts. The corresponding correlations for barrows and gilts were reasonably consistent for the most part. However, only 24 of the correlations were statistically significant for the barrows as compared with 29 for the gilts. The correla-

TABLE 4. SIMPLE CORRELATION COEFFICIENTS BETWEEN LIVE-HOG MEASUREMENTS WITH EACH OTHER AND WITH YIELD OF FIVE CUTS AND YIELD OF LEAN IN HAMS FOR 71 BARROWS AND 70 GILTS

Items	Sex	Height at shoulders	Width at shoulders	Width of middle	Width at hams	Depth at chest	Depth of middle	Circumference	Yield of five cuts[a]	Yield of lean in ham[a]
Length ear to tail	Barrows	+.50**	−.39**	−.50**	−.26*	+.03	−.16	−.33**	+.20	+.08
	Gilts	+.36**	−.35**	−.41**	−.26*	−.05	−.28*	−.40**	+.35**	+.39**
Height at shoulders	Barrows		−.51**	−.41**	−.35**	+.32**	−.23*	−.18	+.41**	+.25*
	Gilts		−.51**	−.39**	−.30*	+.27*	−.34**	−.21	+.50**	+.44**
Width at shoulders	Barrows			+.58**	+.41**	+.04	+.26*	+.43**	−.23*	−.15
	Gilts			+.44**	+.38**	+.18	+.38**	+.56**	−.23*	−.29*
Width of middle	Barrows				+.47**	−.18	+.37**	+.27*	−.40**	−.33**
	Gilts				+.60**	+.11	+.58**	+.55**	−.47**	−.39**
Width at hams	Barrows					+.04	+.25*	+.15	−.08	+.12
	Gilts					+.11	+.49**	+.34**	−.22	+.02
Depth at chest	Barrows						+.13	+.44**	+.37**	+.29*
	Gilts						+.39**	+.57**	+.02	+.16
Depth of middle	Barrows							+.14	−.43**	−.37**
	Gilts							+.51**	−.49**	−.29*
Circumference at chest	Barrows								+.16	−.02
	Gilts								−.34**	−.30*
Yield of five cuts	Barrows									+.72**
	Gilts									+.73**

[a] As percentage of live weight at slaughter.
* Significant at .05 level.
** Highly significant at .01 level.

tions for the yield of the five cuts with length of body, height at shoulders, and depth at chest were in each case positive, while those with width at shoulders, width of middle, width at hams, and depth of middle were negative. The correlation with circumference at chest was positive for the barrows and negative for the gilts.

The betas or standard partial regression coefficients and terms for direct and joint determination of the yield of the five cuts are shown in table 5. The betas for height at shoulders, width at hams, and depth at chest were in each case positive, while those for width of middle and depth of middle were negative. The betas for length of body and width at shoulders are of

TABLE 5. BETAS AND TERMS FOR DIRECT AND JOINT DETERMINATION OF YIELD OF FIVE CUTS (Y) BY EIGHT DIFFERENT BODY MEASUREMENTS

Items	Barrows		Gilts	
	Betas	Squared betas	Betas	Squared betas
Length ear to tail (A)	−.001	.000	+.091	.008
Height at shoulders (B)	+.229 (+.268)*	.052 (.072)	+.340* (+.433)**	.116 (.187)
Width at shoulders (C)	−.040	.002	+.222 (+.138)	.049 (.019)
Width of middle (D)	−.260 (−.181)	.068 (.033)	−.197	.039
Width at hams (E)	+.193	.037	+.168	.028
Depth at chest (F)	+.198	.039	+.164	.027
Depth of middle (G)	−.374** (−.302)**	.140 (.091)	−.349* (−.393)**	.122 (.155)
Circumference at chest (H)	+.213	.045	−.220	.048
Sum of direct terms		.384 (.196)		.437 (.361)
Sum of joint terms		.080 (.118)		.017 (.014)
R^2		.464 (.314)		.454 (.375)
Regression equations	Y=.225B−.195L−.367G+58.5		Y=.466B+.206C−.457G+35.6	

* Statistically significant at .05 level.
** Highly significant at .01 level.

particular interest, being negative for the barrows and positive for the gilts. The beta for circumference at chest was, on the other hand, positive for the barrows and negative for the gilts. While the three latter betas suggest that variations in length of body, width at shoulders, and circumference at chest had opposite effects on the yields of barrows and gilts, there is evidence that sampling errors might account for the apparent sex differences.

The squared betas in table 5 show that in this group of hogs depth of middle had the greatest predictive influence on the yields from both barrows and gilts, followed in order by width of middle, height at shoulders, circumference at chest, depth at chest, width at hams, width at shoulders, and length of body for the barrows and by height at shoulders, width at shoul-

ders, circumference at chest, width of middle, width at hams, depth at chest, and length of body for the gilts. A total of approximately 38 and 44 percent of the variance in the yield of the five cuts from barrows and gilts, respectively, was associated with the eight body measurements acting independently of each other. Joint effects due to inter-relationships between the eight measurements accounted for approximately 8 and 2 percent of the variance. Thus the eight measurements acting singly and jointly accounted for about 46 percent of the variance in the yield of the five cuts from both barrows and gilts. This leaves about 54 percent of the variance due in each case to causes not revealed by the measurements studied. In an attempt to determine the extent to which this residual variance was associated with differences in slaughter weight, the data were re-analyzed with slaughter weight included as one of the variables. When this was done, the residual variance decreased by only about 2 and ½ percent for the barrows and gilts, respectively, indicating that differences in slaughter weight were too small to be of any importance or to need correction.

Since some of the measurements had a very low predictive influence on the yield of the five cuts, the betas were recalculated omitting the five least important measurements. The values for the remaining three measurements are given in parentheses in table 5. These measurements operating independently and jointly accounted for about 31 and 38 percent of the variance in the yields from barrows and gilts, respectively. These figures represent decreases of about 15 and 8 percent below the variances previously attributed to the eight measurements. Thus the combination of height at shoulders, width of middle, and depth of middle in the case of barrows, and the combination of height at shoulders, width at shoulders, and depth of middle in the case of gilts, had almost as high values for their influence on the yields of the five cuts as all eight measurements considered together.

Within the limits of these data, the regression equations in table 5 indicate that for each cm. increase in height at shoulders the yield of the five cuts from barrows might increase by about 0.22 percent, while for each cm. increase in width of middle and depth of middle it might decrease by about 0.20 and 0.37 percent, respectively. For gilts the regression equation indicates that for each cm. increase in height at shoulders and width at shoulders, the yield of the five cuts might increase by about 0.47 and 0.21 percent, respectively, while it would decrease by 0.46 percent for each cm. increase in depth of middle. Since the amount of variation in yield associated with the various measurements constitutes only a relatively small part of the total variation, it should be emphasized that these estimates are subject to considerable error when comparing individual animals. They should, however, be fairly reliable when comparisons are based on group averages.

Relation of body measurements to yield of lean meat in hams

The correlation coefficients between the various body measurements and the yield of lean meat in the hams are given in the last column of table 4. These correlations are similar, in general, to the corresponding correlations with yield of the five cuts.

Table 6 shows the betas and terms for direct and joint determination of the yield of lean meat in the hams by the eight measurements. These betas are fairly consistent with those in table 5 in that most of them reveal similar

TABLE 6. BETAS AND TERMS FOR DIRECT AND JOINT DETERMINATION OF YIELD OF LEAN MEAT IN HAMS (Y) BY EIGHT DIFFERENT BODY MEASUREMENTS

Items	Barrows		Gilts	
	Betas	Squared betas	Betas	Squared betas
Length ear to tail (A)	−.160	.026	+.173	.030
Height at shoulders (B)	+.176	.031	+.160	.026
Width at shoulders (C)	+.045	.002	−.022	.000
Width of middle (D)	−.343* (−.398)**	.118 (.158)	−.275 (−.651)**	.076 (.424)
Width at hams (E)	+.379** (+.391)**	.144 (.153)	+.457** (+.391)**	.208 (.153)
Depth at chest (F)	+.243	.059	+.360* (+.193)	.130 (.037)
Depth of middle (G)	−.351** (−.319)**	.123 (.102)	−.252	.063
Circumference at chest (H)	−.094	.009	−.261	.068
Sum of direct terms		.512 (.413)		.601 (.614)
Sum of joint terms		−.125(−.116)		−.130 (−.320)
R^2		.387 (.297)		.471 (.294)
Regression equations	Y=−.222D+.326E−.200G+13.76		Y=−.378D+.350E+.172F+2.78	

* Statistically significant at .05 level.
** Highly significant at .01 level.

trends. As shown in the lower part of table 6, the eight measurements operating independently and jointly accounted for approximately 39 and 47 percent of the variance in the yield of lean meat in the hams from barrows and gilts, respectively. A comparison of these values with the corresponding values in table 5 shows that while about equal proportions of the variance in the yield of five cuts and in yield of lean meat in hams were accounted for by the eight measurements in the gilts, their predictive influence on yield of lean meat in hams from barrows was less by about 7 percent.

The betas obtained for the three measurements having the greatest influence on yield of lean meat in hams after omitting the other measurements are given in parentheses in table 6. It is evident from the size of these betas that width of middle and width at hams were the two most important of the measurements used, followed by depth of middle for the barrows and by

depth at chest for the gilts. These two sets of measurements operating independently and jointly had approximately the same predictive influence for barrows and gilts, accounting for about 30 percent of the variance in each case. These figures represent decreases of about 9 and 18 percent below the respective variances previously ascribed to the eight measurements. This means that the influence of the three most important measurements was about $\frac{3}{4}$ and $\frac{3}{5}$ as important as that of the eight measurements combined. Although these results might justify the inclusion of additional measurements, it is questionable whether this would be profitable from the practical standpoint.

The regression equations in table 6 indicate that for each cm. increase in width of middle and depth of middle, the yield of lean meat in hams from barrows might decrease by about 0.22 and 0.20 percent, while for each cm. increase in width at hams it might increase by 0.33 percent. The regression equation for the gilts indicates that for each cm. increase in width of middle the yield in lean meat might decrease by 0.38 percent, but might increase by 0.35 and 0.17 percent for each cm. increase in width at hams and depth at chest, respectively.

Summary

Data on 141 hogs fed in Record of Performance trials at Beltsville, Md., in the fall of 1947 were used to determine the relative value of certain body measurements for predicting (a) the combined yield of ham, loin, bacon, picnic shoulder, and shoulder butt, and (b) the yield of lean meat in the hams. The eight live-hog measurements studied were: length from ear to tail, height at shoulders, width at shoulders, width of middle, width at hams, depth at chest, depth of middle, and circumference at chest.

An analysis of the data with respect to the repeatability of single measurements on the same hog gave repeatability values ranging from 0.558 for height at shoulders to 0.767 for width of middle. Repeatability values estimated on the basis of averages of four measurements were found to be considerably higher than those based on only one measurement.

Gilts averaged about 0.8 cm. less in width of middle and yielded about 1.0 percent more of the five cuts and about 0.72 percent more lean meat in the hams than barrows of the same weight and breeding.

For both barrows and gilts, depth of middle was the most important item in determining the yield of the five cuts. Next in importance were width of middle and height at shoulders for the barrows and height at shoulders and width at shoulders for the gilts.

From the analysis of the yield of lean meat in the hams it was found that width at hams was the most important of the measurements for barrows

as well as for gilts. This was followed by depth of middle and width of middle for the barrows and by depth at chest and width of middle for the gilts.

Regression equations are presented for predicting yield of five cuts and yield of lean meat in hams from certain of the eight body measurements studied.

Although the predictive value of the measurements studied was not as great as might be desired, it is concluded that the use of certain body measurements offers possibilities of being a valuable tool in estimating carcass yields from the live animal.

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THE EFFECT OF THYROPROTEIN ON THE GROWTH AND CARCASS COMPOSITION OF SWINE[1]

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PREVIOUS studies by Beeson *et al.* (1947, 1949) and Perry *et al.* (1948) indicated that a hyperthyroid condition brought about by the addition of thyroprotein to the ration of growing, fattening hogs resulted in significantly increased growth rate and increased feed efficiency. Similarly, Reineke, McMillen *et al.*, (1947, 1948) reported increased gain and increased feed efficiency in three breeds of hogs although a fourth breed failed to respond. Vander Noot *et al.*, (1948) reported that the feeding of thyroprotein at levels up to 0.225 gram per 100 pounds liveweight per day for pigs up to a liveweight of 125 pounds, had no effect on growth rate whereas higher levels reduced growth. Braude (1947) and Muhrer *et al.* (1947) were unable to increase growth rate in swine by the feeding of thyroprotein.

Very little investigation has been made of the effects of induced hyperthyroidism on the chemical composition of the carcass. Earlier studies by Beeson *et al.* (1949) and Perry *et al.* (1948) have indicated there are anatomical differences in the carcasses of hogs which have been fed thyroprotein when compared with carcasses of hogs of the same liveweight which have received no thyroprotein in their ration. Some effects of hypothyroidism on the chemical and physical characteristics of the carcass have been reported. McMillen *et al.* (1947) and Acevedo *et al.* (1948) found that the standard carcass measurements and the weights of the standard cuts were not affected by the feeding of thiouracil to swine. Terrill *et al.* (1948) found no differences in the chemical composition of the carcasses of swine which had received thiouracil in a four-week paired-feeding trial. Muhrer *et al.* (1947) reported that the feeding of thiouracil to swine resulted in 3 percent more water and 3 percent less fat in the lean of the loin. Andrews and Bohren (1947) reported that the carcasses of broilers fed thiouracil contained over twice as much fat as those of the controls.

The objectives of this trial were to study further the effects of induced hyperthyroidism on the growth of hogs and also its effects on the chemical composition of the carcass.

[1] Contribution from the Department of Animal Husbandry, Journal Paper No. 406, Purdue University Agricultural Experiment Station, Lafayette, Indiana.

[2] The authors are grateful to Kingan and Company, Indianapolis, Indiana for establishing a grant to support this research and to Dr. W. R. Graham, Jr., Cerophyl Laboratories, Kansas City, Missouri, for the thyroprotein.

Materials and Methods

Purebred Duroc weanling pigs were fed a basal ration which had the following composition: ground yellow corn, 65.75 percent; ground wheat, 20 percent; Purdue Supplement V,[3] 13 percent; minerals,[4] 1 percent; cod liver oil, 0.25 percent.

Forty pigs were divided into four lots in which lot I served as the control and received only the basal ration. The other three groups received, in addition to the basal ration, 0.0088 percent thyroprotein (4 gm. per 100 lb, feed), 0.0132 percent thyroprotein (6 gm. per 100 lb. feed), and 0.0176 percent thyroprotein (8 gm. per 100 lb. feed), respectively.

At the conclusion of the trial the animals were slaughtered and standard carcass measurements as outlined by the Association of Official Agricultural Chemists (1945) were made. In addition, representative carcasses were selected and analyzed for water, protein, fat and mineral matter. These determinations were carried out in duplicate as outlined by the Association of Official Agricultural Chemists (1945). In order to obtain a representative sample from each carcass, one half of each carcass to be analyzed was skinned, boned out, and thoroughly ground and mixed in a sausage grinder. Bones, skin, and carcass meat were weighed separately for each animal. A two pound sample was taken from each ground carcass and this sample was thoroughly mixed in a Hobart Food Cutter before aliquots were taken for chemical analysis.

The carcasses from the 10 hogs of the fastest gaining group (Lot III), the carcasses from 9[5] of the 10 animals from the control group (Lot I), and the carcasses from 3 animals from Lot II were taken for chemical analysis. The 3 animals from Lot II were selected because their liveweights paired up with liveweights of animals in Lot I which could not be matched in Lot III.

Results and Discussion

Influence of Thyroprotein on Growth, Feed Consumption, and Feed Efficiency

As summarized in table 1, the addition of thyroprotein to the basal ration at levels of 0.0088 percent, 0.0132 percent, and 0.0176 percent, resulted in a significantly increased ($P<.05$) rate of growth. These three groups made average gains of 187 pounds, 195 pounds, and 186 pounds, respectively as compared to the control group which gained 154 pounds in the 119 day feeding period.

Although all groups receiving thyroprotein consumed more feed per day

[3] Purdue Supplement V consists of soybean oil meal, 40; fish meal, 20; meat scraps, 20; alfalfa meal, 10; and cottonseed meal, 10 pounds.

[4] Mineral mixture consists of equal parts of ground limestone, steamed bone meal, and salt.

[5] One animal was condemned because of an arthritic condition.

TABLE 1. THE EFFECT OF THYROPROTEIN ON GROWTH, FEED CONSUMPTION, FEED EFFICIENCY, AND CARCASS MEASUREMENTS
(119 days)

Items compared	Lot I Control	Lot II 0.0088% thyro-protein	Lot III 0.0132% thyro-protein	Lot IV 0.0176% thyro-protein
	Growth and Feed Data			
Number of pigs	10	10	10	10
Initial weight, lb.	42	41	41	42
Final weight, lb.	196	228	236	228
Gain per pig, lb.	154	187[1]	195[1]	186[1]
Daily gain per pig, lb.	1.30	1.57	1.64	1.57
Daily feed per pig, lb.	5.42	6.18	6.66	6.34
Feed per 100 pounds gain, lb.	417	395	406	405
Thyroprotein per day, gm.	—	0.247	0.402	0.504
Thyroprotein per 100 pounds live-weight per day, gm.	—	0.200	0.309	0.394
	Carcass Data			
Carcass length, in.	28.8[2]	29.4	29.8	30.4[3]
Leg Length, in.	20.0	20.3	20.7	21.1
Chest depth, in.	14.8	15.3	15.6	15.8
Chest depth (lean only) in.	11.8	11.9	12.1	12.3
Back fat depth				
1st rib, mm.	55	61	61	64
7th rib, mm.	43	50	48	50
Last rib, mm.	37	42	40	42
4th lumbar, mm.	42	46	47	49

[1] Least significant difference for gain in weight at the 5 percent level is 30 pounds.
[2] This represents carcass studies from 9 of the original 10 animals as one animal was condemned.
[3] This represents carcass studies from 8 of the original 10 animals as two animals were retained for pathological studies.

than the control group, the hogs fed thyroprotein required less feed per 100 pounds gain.

Influence of Thyroprotein on Standard Carcass Measurements

Statistical analysis was not made on the carcass measurements. However, these data (table 1) indicate that the greater growth attained by the animals receiving thyroprotein was reflected in carcass measurements of greater magnitude at essentially the same age.

Influence of Thyroprotein on the Chemical Composition of the Carcass

Twenty-two of the 37 carcasses were boned, skinned, and ground for analysis. For the best comparisons of the effect of thyroprotein on carcass

composition it was decided to compare carcasses of the animals from the control group with those of the animals from the fastest gaining group (Lot III). In addition, the carcasses of three animals whose liveweights were approximately the same as three animals from Lot I were taken from Lot II for analysis. No carcasses of the animals from Lot IV were taken for analysis.

The carcasses of the animals from Lot III (0.0132 percent thyroprotein) contained significantly more ($P < .05$) fat than the controls. The carcasses of the control animals contained significantly more ($P < .05$) moisture, protein and mineral matter than those of the animals from Lot III. However, from table 2 it may be observed that the average liveweight of the animals from Lot I which were used for analysis was 202 pounds, while the average liveweight of the animals from Lot III was 236 pounds. When the differences

TABLE 2. THE EFFECT OF THYROPROTEIN ON CHEMICAL COMPOSITION OF CARCASSES

Hog number	Live weight	Moisture, percent	Protein, percent	Fat, percent	Ash, percent	Total
			Lot I—Controls			
1	264	37.26	9.56	52.17	.53	99.52
2	162	44.93	10.44	44.33	.57	100.27
3	245	36.88	9.50	52.58	.52	99.48
4	215	36.16	8.88	54.53	.60	100.17
5	184	41.43	11.13	47.38	.53	100.47
6	229	32.96	8.31	58.53	.42	100.22
7	165	38.91	9.50	51.22	.50	100.13
8	222	36.27	8.88	54.99	.45	100.59
9	136	38.95	9.13	51.15	.56	99.79
Average	202	38.19	9.48	51.88	.52	
			Lot II—0.0088 percent thyroprotein			
12	164	36.09	9.13	54.22	.47	99.91
16	303	33.14	8.63	57.74	.49	100.00
19	209	35.77	9.63	54.36	.48	100.24
			Lot III—0.0132 percent thyroprotein			
21	227	34.88	9.75	55.24	.49	100.36
22	172	38.87	9.69	50.81	.53	99.90
23	258	30.85	8.25	60.82	.35	100.27
24	240	36.63	9.56	53.45	.49	100.13
25	257	34.16	8.13	57.07	.42	99.78
26	251	35.06	9.38	54.76	.47	99.67
27	239	33.06	7.81	58.80	.39	100.06
28	225	37.69	9.31	52.07	.50	99.57
29	223	33.93	8.38	57.32	.46	100.09
30	272	34.78	8.25	56.11	.45	99.59
Average	236	34.99	8.85	55.65	.46	

were analyzed by covariance to adjust for the differences in liveweight there was no significant difference between the two groups in moisture, protein fat or mineral matter content.

Discussion

Within limits, growth rate may be increased by an induced hyperthyroid condition in swine. Beeson *et al.* (1947, 1949) and Perry *et al.* (1948) have been able to increase the growth rate of Durocs from 14 to 27 pounds over control animals by the feeding of thyroprotein. Similar results were reported by Reineke and McMillen (1947, 1948). However, Vander Noot *et al.* (1948), Braude (1947), and Muhrer *et al.* (1947) were not able to get an increased growth rate by feeding of thyroprotein. It is worthy of note, however, that Vander Noot concluded his trials when the animals weighed 125 pounds and it has been observed in every Purdue trial that it is not until after this weight that the accelerated growth rate of thyroprotein-fed pigs is apparent. There may be other factors besides level of feeding of thyroprotein such as age, breed, diet, and climate which may affect the response of hogs to thyroprotein feeding.

Half-carcasses from thyroprotein-fed animals had a greater percentage of fat and lower percentages of moisture, protein, and mineral matter than did those from the control group. When adjustment was made for the difference in liveweight of two groups by use of the regression coefficient there was no significant difference in composition between the two groups. In contrast, Zorn and Brugermann (1939) and Muhrer, *et al.* (1947) reported that induced hypothyroidism resulted in carcasses that contained more moisture and less fat than carcasses from animals which had received no thiouracil. Apparently in the trial reported here, the feeding of thyroprotein had no effect on carcass composition other than that in a given period of time it resulted in the production of heavier carcasses which, in turn, differ in composition from light carcasses. This is borne out by investigations of Blunn and Baker (1947) and Willman and Krider (1943) who reported there was a highly significant correlation between liveweight and such physical characteristics as thickness of back fat, area of loin-eye muscle, and area of lean in the end cut of ham.

Summary

Significantly increased ($P < .05$) growth rate was obtained by the feeding of thyroprotein at levels of 0.0088 percent, 0.0132 percent, and 0.0176 per cent of the ration of growing, fattening swine.

Less feed per unit of gain was required by all animals receiving thyro protein in their ration.

When compared on the same age basis, hogs receiving thyroprotein had a higher percentage of fat and lower percentages of moisture, protein, and mineral matter than animals receiving no thyroprotein.

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EFFECT OF METHYL THIOURACIL AND THIOURACIL IN SWINE[1]

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SINCE the work of Muhrer and Hogan (1945) many investigators have induced a hypothyroid condition in swine by feeding thiouracil. The different levels of thiouracil included in the ration, variation in breed and age of swine employed, and season of the year when the experiment was conducted have undoubtedly influenced the results. Following the availability of a new goitrogen, methyl thiouracil,[2] we became interested in determining its influence in the ration of swine.

Materials and Methods

Three feeding trials were conducted. Two were of a preliminary nature in an attempt to determine the optimum level of methyl thiouracil in the ration of fattening swine, and the third trial was made to compare the optimum levels of methyl thiouracil and thiouracil.[3] In the first trial purebred Berkshires were used and in the second and third experiments purebred Durocs and Berkshires were used. In all of the trials the pigs were maintained on the experimental rations until the time of slaughter.

In the fall of 1947 four groups of 6 hogs each were fed various levels of methyl thiouracil at a cooperating state institution.[4] The basal ration consisted of 76 percent ground yellow corn, 5 percent each of alfalfa leaf meal, malt sprouts, and wheat middlings; 1.25 percent each of meat scraps and fish meal, 2.5 percent each of soybean and linseed meal, and 1.5 percent minerals. This ration was self-fed to the 4 groups: group 1 received the basal ration alone; groups 2, 3 and 4 were fed the basal ration to which had been added 0.05, 0.10, and 0.25 percent methyl thiouracil respectively. The groups were fed for a period of 41 days and each group was weighed at the beginning and end of the trial.

In the spring of 1948 three groups of 3 pigs each were self-fed a basal ration which consisted of 72 percent corn, 8 percent alfalfa leaf meal, 9 percent

[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station, Rutgers University, The State University of New Jersey, Departments of Animal Husbandry and Dairy Industry.

[2] The methyl thiouracil (Methacil) was kindly furnished by Thiokol Corp., Trenton, N. J., through the courtesy of Dr. S. M. Martin, Jr.

[3] The thiouracil (Deravet) was kindly supplied by the Lederle Laboratories, Pearl River, N. Y., through the courtesy of Dr. Mark Welsh.

[4] Bordentown State Prison Farm. Acknowledgment is made to William Houston and Richard Wills for their permission to carry on the experimental work, and to Michael Lisehora, swine herdsman, for his assistance.

each of tankage and soybean meal, and 2 percent minerals. Group 5 served as a control group and received the basal ration alone; and, groups 6 and 7 received the basal ration to which had been added 0.10 and 0.25 percent methyl thiouracil. The rations were fed for a 42-day period and the groups were weighed at the beginning and end of the trial.

The third trial, conducted in the fall of 1948, consisted of 4 groups of 8 pigs each. The basal ration was that used in the previous experiment and was self-fed. Group 8 was fed the basal ration; groups 9 and 10 received 0.05 and 0.10 percent of methyl thiouracil, respectively, in the basal ration; and,

TABLE 1. INFLUENCE OF METHYL THIOURACIL ON WEIGHT GAINS AND FEED CONSUMPTION IN SWINE (41-DAY FEEDING PERIOD)

Group No.	MT treatment*	No. of animals	Avg. initial weight	Avg. final weight	Avg. gain in weight	Avg. daily gain	Feed consumed per 100 lbs. gain
			lbs.	lbs.	lbs.	lbs.	lbs.
1	Control	6	162	213	52	1.29	742
2	0.05	6	150	203	53	1.33	531
3	0.10	6	147	207	60	1.50	472
4	0.25	6	168	220	52	1.29	645
5	Control	3	136	210	74	1.76	408
6	0.10	3	136	202	66	1.57	230
7	0.25	3	137	161	23	0.56	491

* Percentage of methyl thiouracil in feed.

group 11 was fed the basal ration to which had been added 0.25 percent thiouracil. The pigs in each group were weighed individually once a week during the 41-day feeding period. The data from this trial were treated statistically by the method of analysis of variance as outlined by Snedecor (1946).

Liver and lean shoulder meat were dried according to the method previously employed (Vander Noot, Reece, and Skelley, 1948). The goitrogenic activity of the meat was estimated by a rat assay method.

Results and Discussion

In the first trial, group 1 gained an average 1.29 pounds per day and required 742 pounds of feed for each 100 pounds of gain (table 1). Groups 2, 3, and 4 gained an average of 1.33, 1.50, and 1.29 pounds per day, respectively. For each 100 pounds gain group 2 required 531 pounds of feed, group 3 required 472 pounds, and group 4 required 645 pounds of feed. The hogs in

group 4 wasted feed. It is believed that this was probably due to the high methyl thiouracil content of the ration since the other groups did not waste feed.

In the second trial, groups were fed a ration containing 0.10 and 0.25 percent methyl thiouracil since the former concentration appeared to be optimum and the latter concentration resulted in a wasting of feed in the first trial. The average daily gains in groups 5, 6, and 7 were 1.76, 1.57, and 0.56 pounds, respectively (table 1). Group 6 required 29 percent less feed per unit of gain than did the control group. Group 7, as did group 4 in the first

TABLE 2. INFLUENCE OF METHYL THIOURACIL AND THIOURACIL ON WEIGHT GAINS AND FEED CONSUMPTION IN SWINE (42-DAY FEEDING PERIOD)

Group	Treatment M.T. or T.*	No. of animals	Avg. initial weight	Avg. final weight	Avg. gain in weight	Avg. daily gain	Feed consumed per 100 lbs. gain
			lbs.	lbs.	lbs.	lbs.	lbs.
8	Control	8	114	197	83	2.01	420
9	0.05 M.T.	8	112	183	71	1.74	322
10	0.10 M.T.	8	114	181	67	1.63	345
11	0.25 T.	8	114	176	62	1.52	381

* Percentage of M.T. (methyl thiouracil) or T. (Thiouracil) in feed.

trial, wasted feed, again indicating that the methyl thiouracil content of the ration was too high.

Methyl thiouracil was compared with thiouracil in a third trial (table 2). Thiouracil was fed at a 0.25 percent level since earlier work had shown this to be the optimum level. Methyl thiouracil was fed at 0.05 and 0.10 percent levels.

The control pigs, group 8, had the highest average daily gain (2.01 pounds), however, they required the greatest amount of feed per unit of gain. Group 9 required the least amount of feed (322 pounds) for each 100 pounds of gain and were next to the controls in average daily gain (1.74 pounds). Group 10 gained an average of 1.63 pounds daily and consumed 345 pounds of feed per 100 pounds of gain. Group 11, the thiouracil group, had the smallest average gain of the 4 groups, 1.52 pounds. They consumed more feed than either of the groups receiving methyl thiouracil, but less than the control group (table 2). An analysis of variance of the data of this trial showed that the differences in gains in weight were not significant.

One hundred grams of fresh liver from pigs fed a ration containing 0.10 percent methyl thiouracil for 42 days exhibited goitrogenicity similar to that

exhibited by 0.5 of a mg. of methyl thiouracil. By the rat assay method employed it was impossible to detect goitrogenic activity in the lean, shoulder meat. One hundred grams of fresh liver from pigs fed a ration containing 0.25 percent methyl thiouracil for 42 days exhibited a goitrogenicity similar to that shown by 0.10 of a mg. of methyl thiouracil. The lean shoulder meat of these animals showed no goitrogenic activity.

These data indicate that methyl thiouracil is a potent goitrogen in swine and that the optimum level in the ration may be between 0.05 and 0.10 per cent. Methyl thiouracil at these levels was more effective than 0.25 per cent thiouracil. There is an indication that the optimum level for the heavier hogs is higher than that for the lighter hogs. Greater daily gains were observed in the experimental hogs than in the controls when the initial body weight was above 146 pounds but not when it was below 137 pounds.

Summary

Methyl thiouracil is a potent goitrogen when fed to swine. The inclusion of 0.25 percent methyl thiouracil in the feed was less effective than either 0.05 or 0.10 percent. Methyl thiouracil at 0.05 and 0.10 percent levels was more effective than thiouracil at a 0.25 percent level.

Daily gains made by hogs receiving methyl thiouracil, as compared with gains made by control hogs, appeared to be related to initial body weight. Above 146 pounds the experimental hogs gained more rapidly but below 137 pounds they gained less rapidly than the control hogs.

In three trials, hogs fed a ration containing 0.10 percent methyl thiouracil required 36, 29, and 18 percent less feed per unit of gain than did the control hogs. In two trials hogs fed a ration containing 0.05 percent methyl thiouracil required 28 and 23 percent less feed than did the control hogs.

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CARCASS COMPOSITION AND NITROGEN BALANCES OF SWINE FED THIOURACIL[1]

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IN THIS study, the carcass characteristics, carcass composition and nitrogen balances of fattening swine fed the control ration and the control ration plus 0.15% thiouracil are compared. Thiouracil caused partial inhibition of skeletal growth and lowered dressing percentage. It had no significant effect on physical or chemical composition of the carcass, thickness of backfat, carcass grade and carcass firmness, but caused greater retention of nitrogen in the body during the second and third weeks of feeding in comparison with controls.

McMillen, Reineke, Bratzler and Francis (1947) reported no significant differences in carcass measurements for controls and pigs fed 0.1% thiouracil. Muhrer *et al.*, (1947) reported that thiouracil-fed pigs contained about 3% more water and about 3% less fat than did controls. The dressing percentage of the two groups was the same. Willman, Asdell and Loosli (1949) reported that backfat from pigs fed 0.1% thiouracil contained significantly more moisture and had a significantly higher iodine number than back-fat from controls. They further reported that in the hams of thiouracil-fed pigs the fat and skin were more highly developed than in controls.

The results of 7 experiments in which 109 fattening swine were fed by Terrill *et al.*, (1949) showed that 0.15% thiouracil in the ration produced optimum rate and efficiency of gains. It is the purpose of the present paper to report the effect of feeding 0.15% thiouracil on (1) physical carcass characteristics (carcass measurements, cutting yields and slaughter data), (2) carcass composition (amount of mechanically separable fat, lean, bone and skin in the carcass and the percentage of dry matter, ether extract and total nitrogen in samples of separable fat and lean) and (3) the utilization of protein (nitrogen balance determinations).

Experimental Procedures

Carcass data are presented from pigs fed in Experiments 3, 4, and 6 and nitrogen balance data from pigs fed in Experiment 7 of the report by

[1] The data contained in this paper are from research by the senior author in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in Animal Science, University of Illinois.

[2] The authors gratefully acknowledge the donation of the thiouracil by the Lederle Laboratories, Pearl River, New York, through the courtesy of Dr. T. H. Jukes.

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Terrill, Krider, Hamilton and Carroll (1949). In Experiment 3 (control vs. 0.15% vs. 0.20% thiouracil) Duroc barrow trio mates averaging 164 pounds initially were fed for a 42-day period. All pigs were slaughtered at the end of the test. In Experiment 4 (control vs. 0.15% thiouracil) 30 fattening pigs averaging 170 pounds initially were divided into 2 lots and self-fed for a 42-day period. Five barrows from each lot were slaughtered at the end of the test. In Experiment 6 (control vs. 0.15% thiouracil) 7 pairs of barrows averaging 175 pounds initially were pair-fed to gain equally during a 28-day period. All pigs were slaughtered at the end of the test. Six pairs of barrows averaging 142 pounds initially were pair-fed in metabolism cages for 17–18 days in the nitrogen balance test, Experiment 7 (control vs. 0.15% thiouracil).

Carcasses were dressed shipper style, except that they were split down the center. For the carcass composition study (Experiment 6), the entire right side of each carcass was divided into mechanically separable fat, lean, bone and skin. The total weights of fat, lean, bone and skin were recorded for each right side. The lean and fat of each pig were ground separately and samples were analyzed for dry matter, ether extract and total nitrogen.

In the nitrogen balance test (Experiment 7) a pre-collection period of either 7 or 8 days was followed by a collection period of 10 days. The control ration and the control ration plus 0.15% thiouracil were fed the entire 18 days.

In Experiment 4, all data were treated statistically by applying the t-test for unpaired differences (Fisher, 1932). In Experiments 3, 6, and 7, all data were treated statistically by applying the t-test for paired differences (Student, 1908).

Results and Discussion

The Effect of 0.15% Thiouracil on Carcass Characteristics and Composition

The effect of 0.15% thiouracil on physical carcass characteristics was studied in Experiments 3, 4, and 6. The effect on carcass composition was studied in Experiment 6.

Physical Carcass Characteristics. The term physical carcass characteristics is used in a rather broad sense to include slaughter data, cutting yields and carcass measurements. A summary of the slaughter data and carcass measurements obtained in Experiments 3, 4, and 6 appears in table 1.

In Experiment 3, the pigs receiving 0.15% thiouracil gained significantly more rapidly than the controls and averaged 25 pounds heavier at slaughter. In Experiment 4, the 5 control barrows averaged within 2 pounds in live weight of the 5 thiouracil-fed barrows when slaughtered. Pair mates in Experiment 6 were fed to make equal gains, and the average difference in weight

between controls and thiouracil barrows at slaughter time was only 1.2 pounds.

The controls had a higher dressing percentage in all 3 experiments, the difference being statistically significant in Experiment 6. When the data from Experiments 3, 4, and 6 are combined and analyzed by the t-test for unpaired differences, the odds are 14:1 (chilled dressing percent) and 17:1 (warm

TABLE 1. SUMMARY OF SLAUGHTER DATA AND CARCASS MEASUREMENTS FROM EXPERIMENTS 3, 4 AND 6 (DATA REPRESENT AVERAGES FOR EACH GROUP)

Items compared	Exp. 3 Pair-fed (Equal feed)		Exp. 4 Group-fed (Self-fed)		Exp. 5 Pair-fed (Equal gains)	
	Control	0.15% thiouracil	Control	0.15% thiouracil	Control	0.15% thiouracil
Number of barrows	5	5	5	5	7	7
Live weight, lb.	208.8	234.4**	249.4	247.4	224.1	225.3
Warm dressing percentage	79.1[a]	78.4[a]	81.3	80.4	81.8	80.8*
Cold dressing percentage	78.1	77.4	79.5	79.0	80.6	79.6*
Carcass grade[b]	3.8	3.0	2.4	2.4	2.4	2.0
Carcass firmness[c]	2.0	2.8	1.4	1.6	2.1	1.6
Thickness of backfat						
1st thoracic, cm.	5.2	5.2	6.1	6.0	5.6	5.8
13th thoracic, cm.	3.0	3.3	4.1	4.2	3.7	4.0
1st sacral, cm.	3.6	3.5	4.6	4.7	3.7	4.1
Average, cm.	3.9	4.0	4.9	5.0	4.3	4.6
Length of body,[d] in.	29.6	29.1	30.2	28.8*	29.0	28.7
Length of rear leg,[e] in	14.6	14.4	14.7	14.3	14.5	14.2
Circumference of ham,[f] in.	17.7	18.8*	18.6	18.9	25.2	25.2
Depth of body,[g] in.	13.0	13.8	14.0	14.0	13.5	13.4
Thickness of half-carcass,[h] in.	5.3	5.7*	5.7	6.1**	5.7	5.6
Length of foreleg,[i] in.	14.1	13.6*	13.7	13.5	13.2	13.0
Thyroid weight, gm.	7.30	17.18*	8.18	18.98**	—	—

* $P \leq 0.05$, significant.

** $P \leq 0.01$, highly significant.

[a] Average on only two pairs of pigs.

[b] Numbers assigned carcass grades are as follows: Choice +, 1; choice, 2; choice −, 3; good +, 4; good, 5; and good −, 6. Carcass grade was irrespective of firmness of carcass.

[c] Numbers assigned to carcass firmness grades are as follows: Hard, 1; medium hard, 2; medium soft, 3; soft, 4; and oily, 5.

[d] Measured from 1st thoracic vertebra to anterior tip of aitch bone.

[e] Measured from anterior tip of aitch bone to bony projection at center of hock joint.

[f] Measured with a string at a point half-way between the aitch bone and hock in Experiments 3 and 4; measured at the natural depression of the tail-ham junction in Experiment 6.

[g] Measured with calipers at a point slightly posterior to the elbow joint.

[h] Measured with calipers at the 1st thoracic vertebra.

[i] Measured from tip of elbow to tip of toe.

dressing percent) that the lower dressing percentage of the thiouracil barrows is due to factors other than chance.

In all 3 experiments thiouracil barrows had shorter carcasses than the controls, the difference being significant in the group-feeding test (Experiment 4). Statistical analysis of the combined data from all 3 tests indicates odds of 34:1 that the shorter carcasses of thiouracil barrows are due to fac-

TABLE 2. SUMMARY OF CUTTING YEILDS (EXPRESSED AS A PERCENTAGE OF THE RIGHT SIDE) OF BARROWS SLAUGHTERED FROM EXPERIMENTS 4 AND 6

Items compared	Experiment 4		Experiment 6	
	Average for controls	Average for 0.15% thiouracil	Average for controls	Average for 0.15% thiouracil
Number of barrows	5	5	7	7
Right side before cutting, lb.	96.4	93.6	88.7	88.6
Rough ham, %	—	—	21.27	21.47
Trimmed ham, %	15.05	15.80*	15.33	15.61
Loin, %	11.06	11.84*	11.40	11.63
Trimmed shoulder, %	13.93	14.47	—	—
Rough picnic, %	—	—	9.58	9.40
Trimmed picnic, %	—	—	8.56	8.34
Boston butt, %	—	—	6.18	6.19
Rough belly, %	—	—	18.10	18.02
Trimmed belly, %	12.67	13.58	13.00	12.77
Leaf fat, %	3.89	3.31	3.63	3.50
Clear plate, %	—	—	3.03	3.15
Fat back, %	—	—	9.14	9.44
Jowl, %	2.88	2.60	2.80	2.65
Cutting fat,[a] %	27.96	26.82	—	—
Lean trimmings, %	4.33	4.24	—	—
Trimmings (fat and lean), %	—	—	15.97	15.71
Percentage loss in trimming				
Ham	—	—	27.96	27.29
Picnic	—	—	10.55	11.18
Belly	—	—	28.16	29.14

[a] Cutting fat included the fat back, clear plate and fat trimmings from the wholesale cuts.

tors other than chance. A similar analysis for length of foreleg and rear leg indicated odds of 6:1 and 30:1, respectively, that the shorter legs of the thiouracil barrows could be ascribed to factors other than chance. Thus, in these tests, 0.15% thiouracil partially inhibited skeletal growth.

No significant differences occurred in carcass grade, carcass firmness and thickness of backfat. The significantly greater circumference of ham for the thiouracil barrows in Experiment 3 might be explained by the fact that the

thiouracil barrows averaged 25 pounds heavier than controls. Thiouracil barrows showed significantly greater thickness of half-carcass in Experiments 3 and 4 and also when the data are combined for all 3 tests. As would be expected, thyroid weights were significantly heavier in the thiouracil barrows.

The results of the cutting yields from the barrows slaughtered in Experiments 4 and 6 are presented in table 2. No explanation is offered for the fact that differences in cutting yields of trimmed ham and loin were significant

TABLE 3. PHYSICAL AND CHEMICAL COMPOSITION OF CARCASSES FROM CARCASS COMPOSITION TEST, EXPERIMENT 6

Items compared	Average for controls	Average for 0.15% thiouracil
Physical Composition		
Weight of right side, lb.	88.7	88.6
Mechanically separable items as a percentage of right side		
Lean, %	33.40	34.33
Fat, %	47.42	46.88
Bone, %	12.55	12.05
Skin, %	4.21	4.15
Chemical Composition		
Separable lean		
Dry matter, %	31.93	30.84
Ether extract, %	11.66	10.41
Total nitrogen, %	3.10	3.15
Separable fat		
Dry matter, %	87.32	86.69
Ether extract, %	83.51	83.12
Total nitrogen, %	0.60	0.58
Boneless pork (fat plus lean)		
Dry matter, %	64.42	63.12
Ether extract, %	53.83	52.44
Total nitrogen, %	1.63	1.67

in Experiment 4 and not in Experiment 6. When the data are combined for both tests and analyzed by the t-test for unpaired differences, the loin makes up a significantly greater percentage of the right side of the thiouracil barrows than for the controls. However, the odds were only 1:1 for this comparison in the carefully controlled paired test (Experiment 6).

Carcass composition. Seven pairs of barrows were pair-fed for equal gains during a 28-day period in Experiment 6 (carcass composition test). It is well-known that carcass composition changes as body weight increases. Carcasses from heavy hogs will usually contain more fat, less water and less protein on

a percentage basis than carcasses from light hogs. By feeding paired pigs for equal gains this difference in body composition due to increased weight gain can be ruled out, and carcass composition changes that occur can be attributed to the experimental treatment with more certainty. A summary of the effect of 0.15% thiouracil on physical and chemical composition is presented in table 3.

The data in table 3 indicate that no significant differences between controls and thiouracil barrows in amounts of mechanically separable lean, fat, skin or bone occurred. Neither was there a significant difference between the two groups in percentage of dry matter, ether extract or total nitrogen of either lean or fat samples. Chemical composition of boneless meat was calculated by summing the values for lean and fat for each pig.

Differences in physical and chemical composition can not be safely attributed to factors other than chance because statistical probabilities are so low. Further testing might find some of the small differences consistent enough to be significant.

Thus, 0.15% thiouracil showed very little effect on carcass characteristics and composition other than a tendency to partially inhibit skeletal growth and to lower dressing percentage.

The Effect of 0.15% Thiouracil on Nitrogen Retention

The object of this phase of the study was to determine the effect of 0.15% thiouracil upon the utilization of protein as measured by nitrogen balance

TABLE 4. SUMMARY OF DATA FOR THE COLLECTION PERIOD OF CONTROL VS. 0.15% THIOURACIL FOR PAIR-FED PIGS ON NITROGEN BALANCE TEST, EXPERIMENT 7

Items compared	Average for control	Average for 0.15% thiouracil
Number of pigs	6	6
Days on collections[a]	10	10
Weight at start of collection period, lb.	148.5	148.1
Weight at end of collection period, lb.	162.2	169.4
Daily feed per pig, lb.	4.26	4.26
Average daily gain (collection period), lb.	1.43	2.22*
Average feed per 100 lb. gain, lb.	303	197**
Nitrogen balance, gm.	125.96	161.82**
Apparent digestibility of N, %	81.77	82.63
Grams of N-balance per lb. body gain, gm.	9.13	7.63**
Daily water consumption per pig, liters	4.62	3.99

* P.0.05, significant.

** P = 0.01, highly significant.

[a] One pair of pigs was on collection only 8 days.

determinations. Twelve Duroc barrows averaging 142 pounds in weight initially were pair-fed the control ration and the 0.15% thiouracil ration while in metabolism cages 17–18 days. Feces and urine were collected during the last 10 days and the nitrogen balance was determined for each pig. Table 4 summarizes the data concerning the collection period.

The pigs receiving 0.15% thiouracil retained significantly more nitrogen than did the controls receiving the same amount of feed. The thiouracil barrows gained at the rate of 2.22 pounds daily compared with 1.43 pounds daily for controls during the 10 days on collection. Collections were procured during the period of time that thiouracil exerts its greatest effect on gains. There was no significant difference between the control and test barrows in apparent digestibility of nitrogen.

In this test, body gains of thiouracil barrows were increased at a faster rate than nitrogen retention was increased. The control barrows retained 9.13 grams of nitrogen per pound of gain and thiouracil barrows retained only 7.63 grams of nitrogen per pound of gain. Assuming that all nitrogen was retained as protein, this means that gains by controls contained 12.6% protein, whereas gains by the thiouracil barrows contained 10.5% protein for this short period of 10 days.

Average daily water consumption was less for thiouracil pigs than for controls; but the difference was not significant (odds 10:1). More data are needed on this phase of the work before definite conclusions can be drawn.

Thus, in the nitrogen balance phase of this study, pigs receiving 0.15% thiouracil retained significantly more nitrogen than did the controls but apparently their gains contained about 2% less protein than gains by control pigs.

Conclusions

Within the limits of the conditions covered in the study, the following conclusions appear justified:

1. Thiouracil fed as 0.15% of the ration causes increased retention of nitrogen in the body during the second and third weeks of feeding, the period of time that the drug causes the greatest increase in daily gains.

2. Neither the physical nor the chemical composition of the carcass is modified significantly when fattening barrows are fed thiouracil during a 4-week period.

3. Thiouracil causes partial inhibition of skeletal growth, lowers dressing percentage about 1%, but has no significant effect on thickness of backfat, cutting yields, carcass grade and carcass firmness.

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THE OCCURRENCE OF ESTRUS AND OVULATION IN POSTPARTUM SOWS[1]

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THE breeding of sows at the postpartum estrus has been reported by farmers; however, little is known concerning the fertility of this breeding. Also, there appear to be no critical data to indicate the incidence of postpartum heats in sows.

Coburn (1906) wrote "that the sow, in most cases, will take the boar from the second to fourth day after farrowing. If she is not served or fails to get with pig she will not, as a general thing, breed again until the pigs have been weaned." Smith (1937) indicates that sows come into heat a few days after farrowing, usually the third, and sometimes again before the pigs are weaned. However, Asdell (1946) states that sows do not usually come into heat during lactation. None of the above authors gives evidence for their statements.

An experiment was planned to clarify the question of the conflicting opinions concerning the occurrence of a postpartum heat in sows. The object of the study was to obtain information on the incidence of postpartum heats, the potential fertility, the condition of the genital organs during the postpartum interval and the influence of suckling upon the occurrence of estrus and ovulation. A preliminary report of this study was made by Warnick, Casida and Grummer (1947).

Materials and Methods

Thirty-six sows were checked daily with a boar for heat beginning one day after farrowing and continued for 10 days or until the end of heat if it occurred. Sows that did not come into heat were killed 10 days after farrowing. Sows that came into heat were bred by natural service and checked at 10–12 hour intervals until the end of heat. These animals were killed 1 to 2 days after the end of heat. The genital organs of all animals were taken to the laboratory soon after slaughter and examined. Counts and measurements were made of follicles and corpora lutea. The pigs were weighed at birth and on alternate days thereafter until the sow was slaughtered. The weights gave an approximate index of the sows' milk production and were used to test the hypothesis, that lactation tends to prevent the occurrence of estrus.

[1] Published with the approval of the Director of the Wisconsin Agricultural Experiment Station. From the Departments of Animal Husbandry and Genetics. Paper No. 406 from the Department of Genetics.

Results and Discussion

The first year's study used twenty-one females (group 1), which included 8 Chester White gilts, 5 Poland China gilts, 5 Duroc gilts and 3 Poland China sows. Nineteen of the 21 females farrowed live pigs and were suckled, table 1. The other two farrowed pigs, but neither was suckled. Six of the 19 suckled females came into heat within 4 days after parturition and were bred to fertile boars. One of the 6 estrous animals lost all her pigs by the second day and was in heat on the fourth day; another came into heat on the second day when all her pigs had died except one. These 6 sows were

TABLE 1. OCCURRENCE OF HEAT AND OVULATION IN POSTPARTUM SOWS

(Group 1, April 1946 to February 1947)

History	Total sows	Heat	Ovulation
Suckled	19	6	0
Non-suckled	2	2	2

killed 1 to 2 days after the end of heat and none had ovulated. The ovaries had no follicles more than 5 mm. in diameter. Thirteen of the suckled animals that did not come into heat were killed at 10 days (11 days in one instance) postpartum. None of these had ovulated and the largest follicles were 7 mm. in diameter.

The two sows that were not suckled came into heat and were bred within 7 days postpartum. They had ovulated (killed 1–2 days after heat) and embryos up to the 8-cell stage were recovered from the oviducts.

The corpora lutea of pregnancy had regressed to a considerable extent in all animals. They ranged in diameter from 3 to 10 mm., and were yellowish-white in color. All of the corpora had regressed in one animal as determined by macroscopic examination. The uterus in most instances had not undergone complete involution and the endometrium was a pinkish-brown color with some hemorrhagic spots on the surface.

The average interval from parturition to heat (table 2) was longer for the nonsuckled than suckled individuals (5.0 vs. 2.8 days), although not statistically different. The longer interval in the nonsuckled animals was due to an interval of 7 days in one sow whereas the interval in nonsuckled animals never exceeded 4 days. Also, the average length of estrus was longer for the nonsuckled than for the suckled (5.0 vs. 1.7 checks). The checks correspond to heat periods approximately 60 and 20 hours in length in the nonsuckled and suckled animals respectively, a difference that was statistically significant.

TABLE 2. THE EFFECT OF SUCKLING UPON THE INTERVAL FROM PARTURITION TO HEAT AND LENGTH OF HEAT IN SOWS

(Group 1)

History	No. sows	Av. interval parturition to heat	Av. no. checks in heat*
		days	
Suckled	6	2.8	1.7
Non-suckled	2	5.0	5.0

* Sows were checked for heat at 10–12 hour intervals after first noted in heat; 1.7 and 5.0 checks equal approximately 20 and 60 hours respectively.

It then appeared that suckling inhibited follicular development and ovulation, since only the 2 nonsuckled cases ovulated although 6 of the 19 suckled animals came into heat and readily accepted the boar. Consequently, for the second year's work, an experiment was designed to test whether or not suckling inhibits follicular development, estrus and ovulation. One-half of the animals were suckled while the remainder were nonsuckled (pigs removed immediately at birth). Animals were assigned to the suckled and nonsuckled class at random before farrowing. These females were checked for heat and bred according to the plan for group 1. One Poland China, 1 Duroc and 6 Chester White gilts were included in the suckled class, while 7 Chester White gilts made up the nonsuckled class. Five gilts in each class came into heat within 3 days postpartum and were mated, table 3; however, none of them ovulated. The 3 suckled and 2 nonsuckled sows that did not come into heat had not ovulated when killed 10 days postpartum. In no case were there follicles above 5 mm. in diameter in the ovaries of the suckled estrous gilts and 6 mm. in nonsuckled estrous gilts when killed 1 to 2 days after the end of heat. One of these nonsuckled animals farrowed only dead pigs but here again ovulation did not occur although she came into heat. This is contrary to the performance of the animal in group 1 that farrowed dead pigs and came into heat and ovulated. There is no clear explanation of the different performance in these two cases.

TABLE 3. OCCURRENCE OF HEAT AND OVULATION IN POSTPARTUM SOWS

(Group 2, April 1947 to July 1947)

Treatment	Total sows	Heat	Ovulation
Suckled	8	5	0
Non-suckled	7	5	0

TABLE 4. THE EFFECT OF SUCKLING UPON THE INTERVAL FROM PARTURITION TO HEAT AND LENGTH OF HEAT IN SOWS

(Group 2)

Treatment	No. sows	Av. interval parturition to heat	Av. no. checks in heat*
		days	
Suckled	5	2.4	4.4
Non-suckled	5	1.4	7.0

* Sows were checked for heat at 10–12 hour intervals after first noted in heat; 4.4 and 7.0 checks equal approximately 53 and 84 hours respectively.

The average interval from parturition to heat in group 2 was longer in the suckled than nonsuckled animals (2.4 vs. 1.4 days), although the difference was not statistically significant, table 4. Four of the 5 nonsuckled animals were in heat at the first check 1 day after farrowing. The length of estrus was longer in the nonsuckled than suckled cases (7.0 vs. 4.4 checks), again not a statistically significant difference. These checks correspond to heat periods approximately 84 and 53 hours for the nonsuckled and suckled animals respectively.

All follicles 2 mm. and larger in diameter were counted and measured at the time of slaughter to determine the effect of suckling upon follicular development. Our hypothesis was that suckling inhibits follicular development and subsequent ovulation. The average follicular volume was 32.6 cc. in suckled estrous animals and 743.4 cc. in nonsuckled estrous gilts, table 5. Also, there was a considerably smaller volume in the suckled nonestrous than nonsuckled nonestrous gilts (223.0 vs. 1755.5 cc.). Analysis of variance,

TABLE 5. EFFECT OF SUCKLING UPON FOLLICULAR DEVELOPMENT IN POSTPARTUM SOWS

(Group 2)

Group	Suckled sows			Nonsuckled sows		
	No. sows	Av. interval parturition to slaughter	Av. follicular volume	No. sows	Av. interval parturition to slaughter	Av. follicular volume
		days	*cc.*		*days*	*cc.*
Estrous sows	3*	6	32.6	5	6	743.4
Nonestrous sows	3	10	223.0	2	10	1755.5

* Information was not complete in 2 animals

table 6, indicates that suckling produces a definite inhibition of follicular activity. The significant difference between estrous and nonestrous animals could have come about because the nonestrous group was killed at 10 days postpartum while the estrous group was killed 6 days after farrowing. The highly significant interaction indicates a lesser inhibitory effect of suckling in the earlier killed estrous animals than in the later killed nonestrous ones.

The effect of the litter upon the performance of the dams was studied by dividing the animals as nearly as possible into two equal groups covering the

TABLE 6. EFFECT OF SUCKLING UPON FOLLICULAR DEVELOPMENT IN POSTPARTUM SOWS

(Group 2) Analysis of Variance

Source of variation	D.f.	Mean square
Estrus	1	396,833*
Suckling	1	2,644,549**
Estrus×Suckling	1	1,120,860**
Error	9	67,453

* P=0.05 ** P=0.01

lower and upper halves, respectively, of the ranges of variation for the different litter characteristics, table 7. These served to furnish evidence supporting or failing to support the hypothesis that lactation has an inhibitory effect upon heat. The percentages of animals showing a postpartum heat did not differ significantly between the "high" and the "low" groups for any of the litter characteristics. Thus, these data fail to establish the original hypothesis.

Estrus occurs typically when nearly mature follicles are present to secrete estrogen, and in turn produce heat. None of these animals was slaughtered during heat but it is suspected that there were no mature follicles at the time of heat and that the small follicles in these sows (2 days after estrus) produced little estrogen and were not responsible for bringing the sows into heat. This would suggest an extra-ovarian source of estrogen in the postpartum sow. One possibility of a source of estrogen is the placenta,[2] which is often eaten by the sow after farrowing. This possibility could not be checked with these data.

Suckling did inhibit follicular activity but this does not explain the anovulatory heat in suckled animals as the nonsuckled ones (group 2) did not ovulate although some showed heat. Suckling (apart from milk secretion) might work through the pituitary to inhibit follicular development; it has been shown by Desclin (1947), that suckling interferes with the gonadotrophic activity of the pituitary gland in rats.

[2] Suggested by Dr. H. H. Cole, University of California, Davis, in personal communications.

It is of interest to note the relatively small proportion of sows that have a postpartum heat, in view of the statements of Coburn (1906) and Smith (1937). Only 31.6 percent of the suckled sows in group 1 and 62.5 percent of those in group 2 came into heat. The discrepancy in the incidence of heat between these two groups is probably due to sampling error. The interval between parturition and heat was fairly constant in suckled sows—in no instance was the interval more than 4 days.

TABLE 7. EFFECT OF SIZE, WEIGHT OF LITTER, AND GAIN OF LITTER UPON POSTPARTUM HEAT IN SUCKLED FEMALES

(Groups 1 and 2)

Litter characteristics	Class range	No. sows	Percentage showing heat
No. pigs farrowed	2–9	14	35.7
	10–13	13	46.2
Av. wt. per pig of all pigs farrowed, lb.*	1.5–2.5	12	25.0
	2.6–3.2	12	58.3
No. live pigs farrowed	2–9	15	33.3
	10–12	12	50.0
Av. wt. per pig of live pigs farrowed, lb.*	1.9–2.5	12	25.0
	2.6–3.4	12	58.3
No. live pigs at 2nd day	1–6	9	55.6
	7–10	11	54.5
Av. gain per pig to 2nd day, lb.*	0.0–0.2	7	58.3
	0.3–1.0	13	38.5

* The pigs of three females early in the experiment were not weighed.

Summary

Data are presented on 36 sows that were checked for a postpartum heat and later killed to determine the condition of the ovaries. Eighteen of the animals came into heat and were bred, but only 2 of the 18 ovulated (pigs dead at birth in one and immediately after birth in the other). None of the nonestrous sows had ovulated when killed 10 days postpartum. An experiment to test the effect of suckling did not show it to be a factor in inhibiting ovulation. There was, however, a lesser follicular volume in suckled sows than in nonsuckled sows. It is suggested that an extra-ovarian source of estrogen is responsible for the postpartum anovulatory heat.

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SUPPLEMENTING RATIONS WITH FOLIC ACID, LYSINE, INOSITOL, BIOTIN, AND ERGOSTANYL ACETATE FOR THE YOUNG PIG[1]

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EXPERIMENTAL work conducted by Krider *et al.* (1946) showed that when gilts, fed a natural grain ration, were given folic acid their pigs were thriftier and more vigorous but weaning weights were not significantly improved, Cunha *et al.* (1947) found, in a preliminary trial, that adding folic acid to the ration of pigs fed a natural grain ration containing tankage did not have any effect on hemoglobin formation although it caused some stimulation of growth during the first four weeks and caused the pigs to be cleaner in appearance and have bigger appetites at the end of the experimental period. Cunha *et al.* (1948) showed that the pig needs folic acid supplementation for adequate hemopoiesis when fed a purified ration for 21 weeks.

The experiment reported herein was undertaken to determine whether folic acid supplementation would be of any benefit to pigs fed various natural grain rations. In addition, a possible interrelationship between folic acid and lysine was studied. Ergostanyl acetate, an "antistiffness factor" for guinea pigs obtained by Oleson *et al.* (1947), was tried with pigs which had already developed a "stiffness" on concrete feeding floors. A possible interrelationship between biotin, inositol, and methionine was also studied.

Materials and Methods

Young Chester White pigs 6 to 10 weeks of age and of varying weights (see tables 1 and 2 were used. The pigs were selected and distributed equally in each lot with respect to initial weights, age, and sex. The pigs were fed in drylot on concrete floors.

The rations fed and nutrients added are given in tables 1 and 2. The feeds used may be described as follows: Wheat and barley—good quality feed grains grown locally; Tankage—dry-rendered, 55 percent protein grade; Fishmeal—herring meal, 64 percent protein grade; Cull peas—grown in

[1] Published as Scientific Paper No. 803. Agricultural Experiment Stations, Institute of Agricultural Sciences, State College of Washington, Pullman, Washington. These studies were supported in part by a grant from Lederle Laboratories, Pearl River, N. Y.

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We are indebted to Dr. D. F. Green and Merck & Co., Rahway, New Jersey, for supplying biotin and inositol. The cooperation of Dr. T. H. Jukes and Lederle Laboratories, Pearl River, N. Y., in supplying folic acid and ergostanyl acetate is gratefully appreciated. The lysine was obtained through the courtesy of Dr. Raphael Schillinger, Interchemical Corporation, Union, New Jersey.

TABLE 1. SUPPLEMENTING NATURAL GRAIN RATIONS WITH FOLIC ACID

Lot no.	1	2	3	4	5	6	7	8	9	10
Protein supplement used[1]	Tankage	Tankage	Tankage and fish meal[2]	Tankage and fish meal[2]	Tankage	Tankage	Tankage	Tankage	Fish meal	Fish meal
Level of protein in ration, percent	18.4	18.4	14.3	14.3	18.4	18.4	15.1	15.1	16.4	16.4
Method of feeding	Pair-fed—1947[3]		Self-fed—1947[3]				Self-fed—1948[4]			
Supplement added	None	Folic acid	None	Folic acid	None	Folic acid	None	Folic acid	None	Folic acid
No. of pigs	4	4	6	6	6	6	6	6	6	6
No. weeks on trial	8	8	5	5	8	8	8	8	11	11
Av. initial wt., lbs.	30.7	31.2	51.0	51.0	29.5	29.8	23.3	25.8	23.5	23.1
Av. daily gain, lbs.	0.42	0.44	0.27	0.38	0.38	0.38	0.50	0.68	0.93	0.96
Av. daily feed consumption, lbs.	1.31	1.31	1.31	2.02	2.09	1.95	1.88	2.52	2.73	2.7:
Lbs. of feed per lb. gain	3.10	3.00	4.80	3.50	5.49	5.15	3.77	3.71	2.94	2.83
Av. Hb. level, grams	10.42	11.43	10.6	9.8	10.7	10.7	10.98	10.88	12.18	11.83

[1] Remainder of ration consisted of wheat and barley (½ of each), 5% dehydrated alfalfa, 0.5% bone meal, 0.5% gr. limestone and 0.5% of iodized salt.

[2] Half of the protein was supplied by each protein supplement.

[3] Crystalline folic acid was fed at a level of 50 micrograms per 100 grams of feed.

[4] Folic acid (Parvo feed supplement) was fed at a level of 100 micrograms per 100 grams of feed.

eastern Washington, largely of the Alaska variety, separated by gravity; Alfalfa meal—ground leaf and stem meal, dehydrated.

Hemoglobin was determined by the method of Evelyn (1936). Ergostanyl acetate was dissolved in refined cottonseed oil and given to the pigs daily in capsules.

Results and Discussion

The data shown in tables 1 and 2 indicate that variable results are obtained in folic acid supplementation of natural rations. In rations containing from 14.3 to 15.1 percent protein (lots 3, 4, 7 and 8), there was an indication that folic acid supplementation might be of some benefit in increasing efficiency of feed utilization and rate of gain. The pigs in lot 4 gained at a significantly greater ($d.f. = 11$, $t = 2.87$*) rate than those in lot 3. In the other case (lot 8) the addition of folic acid did not result in any increase in feed utilization efficiency, although it seemed to increase the rate of gain. This seemingly different response to folic acid might be due to the increased

* Statistically significant.

protein content of the ration and/or to the folic acid content of the ration.

With rations containing 16.4 to 18.4 percent of protein, (lots 1, 2, 5, 6, 9 and 10) folic acid supplementation was of no benefit in increasing rate of gain. These data indicate that the protein level of the ration is related to the folic acid needs of the pig. With a lowered protein intake, it was possible to show a need for folic acid by the pig whereas with an increased protein intake folic acid supplementation was of no benefit. This finding has been substantiated by Ruegamer *et al.* (1948) with dogs where the need for folic acid could not be shown with higher levels of protein. This did not hold true in lots 11 and 12 (table 2) where wheat, barley and mineral ration was fed. In these two lots with a protein content of 10.5 percent in the ration, folic acid supplementation was of no benefit. It must be emphasized, however, that this ration was deficient in other vitamins or in certain essential amino acids which may have prevented any beneficial effect of folic acid.

In lots 11, 12, and 13 a possible interrelationship between folic acid and lysine was studied. This study was conducted since, in a preliminary trial with male rats fed the same ration, both folic acid and lysine were of benefit in preventing alopecia. No alopecia or interrelationship of these two factors

TABLE 2. SUPPLEMENTATION OF RATIONS WITH VITAMINS AND AN AMINO ACID

Lot no.	11	12	13	14	15	16
Ration fed	Wheat 49.5 Barley 49.0 Bone meal 0.5 Limestone 0.5 Iodized salt 0.5 100.0			Sucrose 38.5 Cull peas 60.0 Bone meal 0.5 Limestone 0.5 Iodized salt 0.5 100.0		
Level of protein in ration, percent	10.5	10.5	10.5	15.0	15.0	15.0
Supplement added[1]	None	Folic acid[2]	Lysine[3]	None	Biotin[4]	Inositol[5]
No. of pigs	4	4	4	4	4	4
No. of weeks on trial	11	11	11	11	11	11
Av. initial wt., lbs.	26.0	26.0	25.8	17.0	17.0	17.0
Av. daily gain, lbs.	0.39	0.39	0.47	0.17	0.20	0.15
Av. daily feed consumption, lbs.	1.49	1.54	1.51	0.82	0.78	0.77
Lbs. of feed per lb. grain	3.83	3.94	3.36	5.77	4.65	5.16
Av. Hb. level, grams	10.44	9.36	11.45	11.05	10.10	10.61

[1] Vitamins A, D, E, K, C, thiamine, riboflavin, niacin, pyridoxine, and pantothenic acid were added at same levels as used by Cunha *et al.* (1947).

[2] Folic acid (P G A) was added to the ration at a level of 100 micrograms per 100 grams of feed. Parvo feed supplement, from Lederle Laboratories, Pearl River, New York, was used in supplying the folic acid.

[3] L (+) lysine monohydrochloride was added to the ration at a level of 0.5 percent.

[4] Biotin was fed at a level of 20 micrograms per 100 grams of feed.

[5] Inositol was fed at a level of 0.3 grams per 100 grams of feed.

was obtained with the pigs. Lysine supplementation was of slight help in increasing gains and efficiency of feed utilization which would be expected since the ration is low in this amino acid. The pigs fed lysine would have eaten considerably more than their controls if they had been allowed to.

Throughout all the trials (lot 1 to 13), folic acid supplementation had no effect in stimulating hemoglobin formation. This substantiates previous work with natural rations by Cunha *et al.* (1947).

In lots 14, 15, and 16 a possible interrelationship between biotin, inositol, and methionine was studied. This study was prompted since results, in a preliminary trial with rats fed the same low methionine ration, showed that biotin was of benefit in growth. In this trial with pigs, the biotin was of no help in stimulating growth but tended to increase the efficiency of feed utilization. Due to the small numbers of pigs and the large individual variation, the increase in efficiency of feed utilization was statistically not significant. Inositol was of no benefit in improving rate of gain or efficiency of feed utilization.

Half of the pigs in lots 7 and 8 were each given daily dosages of 250 micrograms of ergostanyl acetate which is approximately the same quantity per unit body weight as used by Oleson *et al.* (1947) who found this compound to be an "antistiffness factor" for the guinea pig. The pigs in lots 7 and 8 had developed a "stiffness" which is usually observed with pigs fed on concrete floors. Ergostanyl feeding was started after the pigs had been on experiment for 42 days. The pigs were fed the ergostanyl acetate for 24 days. No beneficial effect was observed from the compound in curing or alleviating the stiffness with the pigs. Oleson *et al.* (1947) were able to cure the stiffness in guinea pigs in 5 days.

Summary

Variable results were obtained in supplementing natural rations with folic acid depending on the protein content of the ration. With rations containing 14.3 to 15.1 percent protein, folic acid supplementation tended to increase the rate of gain and the efficiency of feed utilization. With rations containing 16.4 to 18.4 percent protein, folic acid supplementation was of no benefit in increasing rate of gain. With the lower protein content rations, folic acid stimulates appetite causing the pigs to consume more feed, thus indicating a relationship between protein level and folic acid needs of the pig.

Folic acid supplementation of the various natural rations studied was of no benefit in hemoglobin formation.

With the pig, under the conditions of this experiment, there was no interrelationship between folic acid and lysine.

With a methionine low ration, biotin was of no benefit in promoting efficiency of feed utilization.

Ergostanyl acetate, a guinea pig "antistiffness factor," was of no benefit in curing or alleviating a stiffness which is characteristic of pigs kept on concrete floors.

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FURTHER STUDIES OF PANTOTHENIC ACID DEFICIENCY IN WEANLING PIGS[1]

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IN A previous study Luecke, Thorp, McMillen and Dunne (1949) showed that locomotor incoordination due to deficiency of pantothenic acid could be produced on low protein rations made up largely of corn. However, in no case was the deficiency severe enough to produce posterior paralysis. These investigators further found that blood levels of pantothenic acid seemed to reflect the levels of this vitamin ingested in the ration.

The present paper deals with the production of pantothenic acid deficiency in weanling pigs fed a low protein corn-soybean ration. Furthermore, the experimental period was lengthened in order to determine whether prolonged deficiency would result in posterior paralysis. It seemed desirable to determine whether blood levels of pantothenic acid would serve as a diagnostic criteria of deficiency, and also whether the supplementation of the corn-soybean ration with thiamine, riboflavin, nicotinic acid and pyridoxine would have any influence on the rapidity with which a deficiency of pantothenic acid could be produced.

Experimental

The pigs used in the experiment were of the Duroc Jersey breed and were pasture raised. The components of the basal ration are shown in table 1. The crude protein content of this ration was 16.4% and the pantothenic acid content as determined microbiologically by the method of Skeggs and Wright (1944) was 4.21 mg. per lb. In addition the ration was fortified with a vitamin A and D concentrate in amounts which supplied 2,000 I.U. of vitamin A and 200 I.U. of vitamin D per pound of feed.

Each of the experimental lots consisted of eight pigs and all animals were fed *ad libitum*. During the experimental period all of the pigs were kept on concrete floors and bedded with wood shavings.

Results

Growth Studies

Pigs in lot 1 received the corn-soybean basal ration plus thiamine, riboflavin, nicotinic acid, calcium pantothenate, pyridoxine and choline in the

[1] Published with the approval of the Director of the Michigan Agricultural Experiment Station as Journal Article No. 1067.

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TABLE 1. COMPOSITION OF BASAL RATION

	Percent
Corn	77
Soybean oil meal (expeller)	20
Complex mineral mixture*	3

* This mineral mixture contained the following (in %): bonemeal, 31.6; ground limestone, 31.6; iodized salt, 31.6; ferrous sulfate, 2.1; magnesium carbonate, 2.0; copper sulfate, 0.2; potassium carbonate, 0.2; manganese sulfate, 0.5; zinc oxide, 0.1; and cobaltous acetate, 0.1.

amounts shown in the footnote of table 2. The growth response of these animals is also shown in table 2. The pigs in this lot appeared to be normal in every respect.

The pigs in lot 2 were fed the corn-soybean basal ration to which only calcium pantothenate was added at a level of 10 mg. per pound of ration. Although the average daily gain of the pigs in lot 2 for the ten-week experimental period was poor, the average gain of the pigs in this lot, during the first five weeks, was only slightly less than the average gain registered by the pigs in lot 1 for the same period. However, during the last half of the experiment the gains of the animals in lot 2 fell far below the gains in body weight made by pigs in lot 1. During this time the pigs in lot 2 became very thin and unthrifty in appearance and their appetites were subnormal. It would seem that deficiencies of other B-vitamin factors accounted for the poor growth response of this lot.

The corn-soybean basal ration was fed to pigs in lot 3. In addition, the ration was fortified with the same B-vitamins as in lot 1 except that calcium

TABLE 2. RESPONSE OF PIGS TO THE VARIOUS EXPERIMENTAL TREATMENTS

(Eight pigs in each lot on trials lasting 10 weeks)

Item	Lot number			
	1[1]	2[2]	3[3]	4[4]
Av. initial wt., lb.	22	23	24	24
Av. daily gain, lb.	1.05	0.62	0.60	0.40
Av. daily feed consumption, lb.	2.50	2.16	1.83	1.56
Lbs. feed per lb. gain	2.38	3.48	3.05	3.91

[1] Pigs in lot 1 received supplementary B vitamins in the following amounts (all values expressed in mg. per lb. of feed): thiamine, 2.5; riboflavin, 5; nicotinic acid, 10; calcium pantothenate, 10; and pyridoxine, 1.5. Choline chloride was also added at a level of 0.05%.

[2] Pigs in lot 2 received only calcium pantothenate at a level of 10 mg. per lb. feed.

[3] Pigs in lot 3 received the same B-vitamins as lot 1 except that calcium pantothenate was excluded.

[4] Pigs in lot 4 received no B-vitamin supplement.

pantothenate was excluded. During the fourth week of the experiment, severe diarrhea was observed in six of the pigs, and by the fifth week all of the pigs showed the same symptoms. The diarrhea was accompanied by lowered appetite and unthrifty appearance. Again, as previously reported by Luecke *et al.* (1949), diarrhea did not last longer than two weeks and, in every case, was followed by the appearance of locomotor incoordination. All of the pigs in this lot showed symptoms of incoordination varying from moderate to severe. By the end of the tenth week of the experiment two of the pigs were completely paralyzed in the hind quarters. All of the pigs in this lot were necropsied and the pathological changes observed in the sciatic nerve were similar to those described by Wintrobe *et al.* (1940) and by Ellis *et al.* (1941).

No synthetic B-vitamins were added to the corn-soybean basal ration fed to the pigs in lot 4. It can be seen in table 2 that the growth response and feed efficiency of these pigs was very poor. Although some diarrhea was noted in several pigs of this lot, and the animals had an unthrifty appearance, no symptoms of locomotor incoordination were noted during the ten-week experimental period. It must be remembered that the pantothenic acid contents of the rations fed to lots 3 and 4 were identical, and since the pigs in lot 4 consumed less feed than did lot 3, the average intakes of pantothenic acid for pigs in lot 4 was approximately 15 percent less than for the pigs in lot 3. It seems evident that with an average daily gain of 0.60 pounds the level of pantothenic acid in the basal ration fed to the pigs in lot 3 was insufficient to prevent deficiency. However, in the case of the pigs in lot 4 in which the average daily gain was only 0.40 pounds the levels of pantothenic acid in the ration were sufficient to prevent any symptoms of incoordination. It is possible, however, that incoordination might have developed had the animals in this lot been kept on experiment for a longer period.

The average daily gains of the pigs in lot 1 were highly significantly ($P<0.01$) greater than the gains made by lots 2, 3 and 4. The average daily gains of the pigs in lots 2 and 3 were significantly greater ($P<0.05$) than those made by pigs in lot 4.

Blood Levels of Pantothenic Acid

During the third, sixth and tenth weeks, the animals were bled and the levels of pantothenic acid determined in the whole blood. The blood was prepared for assay by the method of Ray *et al.* (1947), and the assay was carried out using the organism *Lactobacillus arabinosus*. The average and the range values of pantothenic acid in whole blood for the four experimental lots are shown in table 3. It can be seen that the blood levels of pantothenic acid are very uniform within each lot. The average levels of this vitamin in blood from pigs in lots 1 and 2 are very similar and the

average levels in lots 3 and 4 are also similar although much lower. As previously stated, the pigs in lot 4 showed no symptoms of incoordination. However, it can be seen from table 3 that the levels of pantothenic acid in the blood are almost identical with the levels found in the pigs of lot 3 which developed severe incoordination. It would thus appear to be impossible under practical swine feeding conditions to determine merely by assaying the levels of this vitamin in the blood of affected pigs whether an outbreak of locomotor incoordination was due to pantothenic acid deficiency.

TABLE 3. PANTOTHENIC ACID CONTENT OF WHOLE BLOOD

(All values expressed in μg/ml of whole blood)

Lot Number	Weeks on experiment		
	3	6	10
1	1.37[1] 1.25–1.56[2]	1.24 1.08–1.41	1.77 1.63–1.89
2	1.39 1.25–1.51	1.31 1.08–1.61	1.65 1.43–1.77
3	0.54 0.48–0.60	0.56 0.51–0.64	0.65 0.59–0.71
4	0.56 0.44–0.75	0.54 0.47–0.59	0.67 0.59–0.75

[1] Average.
[2] Range.

Discussion

McMillen *et al.* (1949) have shown that the addition of nicotinic acid, calcium pantothenate and riboflavin to swine rations containing a variety of feedstuffs produced a very marked increase in growth rate. The results of the present investigation showed that the addition of a mixture of synthetic B-vitamins, which did not contain calcium pantothenate, to a corn-soybean diet resulted in very severe symptoms of pantothenic acid deficiency when fed to weanling pigs. On the other hand, if the corn-soybean diet alone is fed, no symptoms of incoordination are produced. The reason for this may be found in the fact that the pigs in lot 4 receiving the unsupplemented diet grew so poorly that the levels of pantothenic acid in the ration were sufficient to prevent symptoms of incoordination. The significantly greater growth rates of the pigs in lot 3 over those of lot 4 on rations containing identical levels of pantothenic acid, indicates that this increased growth rate also increased the dietary requirements for this vitamin to a point where deficiency symptoms developed.

The question of dietary imbalances of B-vitamins in swine feeds is an important one from a practical standpoint. Some commercial protein supplements for swine contain supplementary levels of riboflavin and nicotinic acid. If these same protein supplements contain only minimal levels of pantothenic acid the results obtained by mixing the supplements with corn and feeding in dry lot might be far worse than if the additional riboflavin and nicotinic acid had been omitted. In this case the addition of nicotinic acid and riboflavin could stimulate growth to such an extent that the levels of pantothenic acid in the ration would be insufficient to prevent deficiency.

Summary

Pantothenic acid deficiency was produced experimentally by feeding a low-protein ration containing corn and soybean oil meal supplemented with thiamine, riboflavin, nicotinic acid and pyridoxine. When, however, the unsupplemented corn-soybean ration was fed, no symptoms of locomotor incoordination were produced in the ten-week experimental period. The growth rates of the pigs in the unsupplemented lot, however, were very poor. The reasons for these differences are discussed.

The basal ration used to produce pantothenic acid deficiency contained by analysis, 4.21 mg. of this vitamin per pound.

The addition of calcium pantothenate to the corn-soybean basal ration resulted in significantly greater gains than made by the pigs fed the unsupplemented basal ration.

Two pigs in the pantothenic acid deficient lot were completely paralyzed in the hind quarters.

Blood levels of pantothenic acid in pigs showing symptoms of deficiency were approximately two fifths of those in the normal control group.

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REQUIREMENT OF THE BABY PIG FOR VITAMIN B_{12} FED AS A CONCENTRATE

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IN A previous paper (Neumann *et al.*, 1948) it was shown that the baby pig requires an unidentified growth factor contained in antipernicious anemia liver extract. The deficiency in our basal diet which is supplied by this liver extract was later shown to be vitamin B_{12} (Johnson *et al.*, 1949).

The present study was conducted to determine the quantitative oral requirement of the baby pig for vitamin B_{12}. A preliminary report of this work has appeared (Johnson and Neumann, 1948).

Experimental

Ten 48-hour-old Duroc-Jersey pigs from the University Swine Farm were fed *ad libitum* the alpha-protein "synthetic milk" ration given in table 1. Sulfasuxidine was added at the rate of 2 gm. per liter of milk to inhibit intestinal synthesis of vitamin B_{12}. The technique of feeding and care was similar to that reported previously (Johnson *et al.*, 1947). The pigs were divided into five groups of 2 pigs each, each group being fed a different level of vitamin B_{12} concentrate.[4] The levels of vitamin B_{12} activity compared are given in table 2. The criteria used to determine the adequacy of the test diets were: gross appearance, deficiency symptoms, weight gains, economy of food utilization, and hematopoiesis. Blood samples were taken by heart puncture at 21 days and at the end of the experiment (after 77 days). Bone marrow samples were taken by sternal aspiration at the end of the experimental period, and bone marrow samples were also collected from 5 similar-aged pigs being fed a farm ration while on pasture at the University farm.

At the close of the experiment all pigs were sacrificed, and sections of the spinal cord, sciatic nerve, brain and various segments of the digestive tract were made for histological examination.

[1] We are glad to acknowledge the help of Dr. L. E. Boley of the University of Illinois College of Veterinary Medicine for taking the blood samples by heart puncture.

We are grateful for the generous support of Dr. C. P. Rhoads, Director of the Sloan-Kettering Institute for Cancer Research, New York, in making possible the cooperation of Dr. Thiersch in this work.

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[3] New York, N. Y.

[4] Experimental vitamin B_{12} mixture 8R5704 was generously supplied by Merck and Co., Inc., Rahway, New Jersey, through the courtesy of Dr. D. F. Green.

TABLE 1. COMPOSITION OF ALPHA-PROTEIN "SYNTHETIC MILK"

Ingredient	Percent
Alpha-Protein[1]	29.4
DL-Methionine	0.6
Glucose (Cerelose)	30.9
Lard	30.8
Mineral salts[2]	8.3

These materials were homogenized into a "synthetic milk" containing 13% solids and 4% fat. The following vitamins were added per liter.

Thiamine[3]	0.65 mg.	Biotin	0.01 mg.
Riboflavin	1.30 mg.	Pteroylglutamic acid	.052 mg.
Pyridoxine	1.30 mg.	Ascorbic acid	16.00 mg.
Calcium pantothenate	7.80 mg.	α-Tocopherol acetate	1.00 mg.
Inositol	26.00 mg.	2-Methyl-1,4-naphthoquinone	0.26 mg.
Nicotinic acid	2.60 mg.		
P-Aminobenzoic acid	2.60 mg.	Vitamin A	2000 I.U.
Choline chloride	130.00 mg.	Vitamin D_2	200 I.U.

[1] Alpha-protein was obtained from the Glidden Co., Chicago, Illinois.

[2] Johnson *et al.* (1947) except that Ca lactate replaces $CaCO_3$ in equimolar amount. This accounts for the increase from 6 to 8.3%.

[3] Thiamine hydrochloride, riboflavin, pyridoxine hydrochloride, calcium pantothenate, biotin, nicotinic acid, ascorbic acid, and α-tocopherol acetate were generously supplied by Hoffmann-La Roche, Inc., Nutley, New Jersey, through the courtesy of Dr. J. C. Bauernfeind. Pteroylglutamic acid (Folvite) was supplied by the American Cyanamid Co., Pearl River, New York, through the courtesy of Dr. T. H. Jukes. Inositol was supplied by the A. E. Staley Manufacturing Co., Decatur, Illinois.

Results and Discussion

A summary of the average performance of the baby pigs is shown in table 2. As the level of vitamin B_{12} potency per kilogram of dry matter in the diet rose from 0.0 to 50 micrograms, there was a marked and steady increase in the average weight gains when expressed as multiples of the initial weight.

TABLE 2. PERFORMANCE OF BABY PIGS ON VARIOUS LEVELS OF VITAMIN B_{12} CONCENTRATE

Groups	I	II	III	IV	V
Supplement (gm./liter)	0.0	0.5	1.0	1.5	2.0
Vit. B_{12} potency (mcg./Kg. DM in diet)	0.0	17.0	34.0	51.0	68.0
Number of pigs	1[1]	2	2	2	2
Av. initial wt. (Kg.)	1.81	1.52	1.59	1.55	1.52
Av. final wt. (Kg.)	15.17	13.84	16.45	19.49	19.40
Av. daily gain (Kg.)	.174	.160	.192	.232	.236
Av. final wt. as multiples of initial wt.	8.38	9.11	10.43	12.57	12.96
Av. Kg. DM/Kg. gain	1.73	1.58	1.62	1.45	1.46

[1] One pig died.

The average ratios when thus expressed were 12.76 for all pigs in groups IV and V, as compared to 9.49 for all pigs in groups I, II, and III, which received no supplement or were inadequately supplemented. The difference between these is statistically significant at the 5 percent level.

In order to determine the vitamin B_{12} level in the diet above which there was no change in gain, it was necessary to determine the point of inflection of the plotted weight against the dose (figure 1). With so few pigs on each

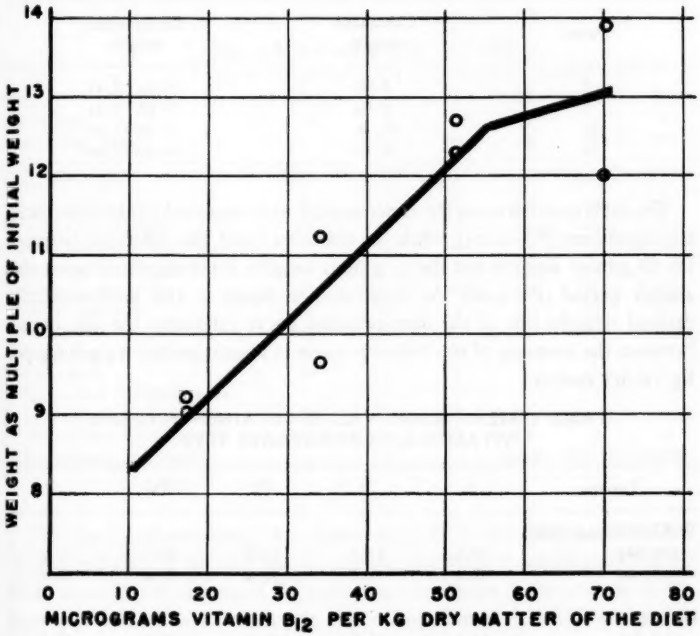

Figure 1. Dose response curve of pigs fed varying levels of Vitamin B_{12} concentrate.

B_{12} level it was necessary to use all of them to establish a requirement. Using the three lower levels (17, 34, and 51 gamma of vitamin B_{12} per Kg. of dry matter) straight-line equations were derived for 8, 9, 10, and 11 weeks of the experiment. These equations are:

8 weeks	$y=4.88+0.056x$
9 weeks	$y=5.56+0.063x$
10 weeks	$y=6.56+0.079x$
11 weeks	$y=7.30+0.10x$

where x = the concentration of vitamin B_{12} activity per Kg. of dry matter in the ration and y = the attained weight in multiples of the initial weight. These equations were then used to calculate the extrapolated values for the 68 gamma per Kg. of dry matter level of feeding. The results of this extrapolation as compared to the data obtained are given in table 3.

TABLE 3. COMPARISON OF CALCULATED AND EXPERIMENTAL WEIGHTS AT 68γ OF VITAMIN B_{12}/KG. D.M.

Weeks	Calculated weight	Experimental weights
8	8.69	7.52, 8.42
9	9.84	8.58, 9.31
10	11.93	10.10, 11.30
11	14.10	11.99, 13.94

The difference between the experimental and calculated values is statistically significant ($P = 0.004$), while, on the other hand, the difference between the 68 gamma weights and the 51 gamma weights is not significant over this 4-week period ($P = 0.08$). As illustrated in figure 1, the mathematically derived straight line of the dose response curve intersects the line drawn between the averages of the two top levels at approximately 54 gamma per Kg. of dry matter.

TABLE 4. MEAN BLOOD VALUES OBTAINED IN CRUDE VITAMIN B_{12} CONCENTRATE TEST

Groups	I	II	III	IV	V
WBC (thousand/cmm.)					
21st day	16.5	17.0	10.8	20.3	15.5
77th day	18.0	14.8	19.3	23.8	20.5
Hb (gm./100 ml.)					
21st day	11.3	11.8	10.9	10.5	10.6
77th day	11.3	12.1	12.5	14.3	13.2

One pig died in the control group during the third week, and after 5 weeks the remaining control pig, as well as those on the two lower levels of supplement, began to develop symptoms of extreme irritability. The pigs were sensitive to touch, showed signs of pain in the posterior body region, and were easily excited, especially during weighing and other operations that necessitated handling them. Two pigs on the lower levels of supplement showed definite signs of voice failure. There was a tendency for the pigs to want to elevate the posterior portion of the body, and they were often

found with their rear legs placed up on the shield protecting the feed dishes. Two pigs on the lower levels made frequent attempts to turn over on their backs, seemingly in an effort to find a more comfortable position.

The blood data given in table 4 show that the hemoglobin increased slightly between the 21st and 77th days on test. The increase in hemoglobin was somewhat greater for the highest levels of vitamin B_{12}. In those cases where a slight anemia occurred, there was no evidence of macrocytosis. There was usually a slight rise in white blood cell count.

TABLE 5. BONE MARROW COUNTS

Group	Farm pigs	I	II	III	IV	V
No. of pigs	5	1	2	2	2	2
Age of pigs, days		77	77	77	67	75
Total cells/mm³	180	230	530	142	254	435
Percent myeloid cells	76	41	37	54	55	54
Percent erythroid cells	23	53	61	44	44	45
Percent lymphoid cells	1	6	2	2	1	1
Differential of myeloid series:						
Mature neutrophils	36	32	20	42	36	46
Metamyelocytes	22	40	32	23	24	21
Myelocytes	29	18	40	28	27	28
Myeloblasts	1	5	4	3.5	2	—
Eosinophils	12	5	4	3.5	1	5
Differential of erythroid series:						
Normoblasts, orthochromic	86	80	81.5	82	95	99
Normoblasts, basophilic	13	17	18	18	5	1
Normoblasts, macrocytic	1	3	.5	present	present	present

The bone marrow counts are shown in table 5. An increase of the nucleated red cells in the marrow of animals receiving no supplement and of those receiving 17 gamma of B_{12} activity per kilogram of diet can be noted. Baby pigs treated with larger amounts of supplement (table 2, groups III, IV and V) containing 34, 51 and 68 gamma of vitamin B_{12} potency per kilogram of diet still showed an increased percentage of nucleated red cells in the marrow as compared to the sow-fed pigs.

On examination all marrows were found to be cellular, and on differential counting no significant changes were detected in the myeloid series.[5] In the red series the number of mature hemoglobinized normoblasts was found to be the greatest in the baby pigs treated with 51 and 68 gamma of B_{12} activity per kilogram of diet. No significant difference was detected between naturally sow-fed animals and those on unsupplemented diets and on low levels of

[5] Except for the increased number of eosinophils in the sow-fed animals. The lymphocytes in the marrow were found to be low in all groups.

supplement. No evidence of primitive erythropoiesis was detected, and only a few primitive large erythroblasts were noted.

No gross or microscopic lesions were observed in the gastrointestinal tract, and there was no splenic enlargement. Histological sections of the brain, sciatic nerve, and spinal cord were made at different levels and were found to be normal.

Discussion

On the basis of the growth data, the oral requirement of the baby pig for vitamin B_{12} appears to be approximately 50 micrograms of vitamin B_{12} activity per kilogram of dry matter in the diet. The addition of more vitamin B_{12} concentrate failed to produce a further increase in growth rate. This requirement is slightly higher than the 30 gamma per kilogram of ration requirement found by Ott *et al.* (1948) for the chick.

Although the rations fed groups IV and V promoted good growth, they did not maintain normal hematopoiesis, as shown by the high total erythroid counts in the bone marrow. A slight normocytic anemia was present in the low-level groups at the end of the test.

The apparent nerve involvement and hyper-irritability appeared similar in nature to the nerve involvement in some cases of pernicious anemia which do not respond to treatment with pteroylglutamic acid (Berk *et al.* 1948). However, no macroscopical or microscopical abnormalities were found in the nervous system, and on examination no lesions of the digestive tract were detected.

Summary

Favorable growth responses were obtained when sufficiently high levels of a vitamin B_{12} concentrate were added to the basal alpha-protein diet, which is low in vitamin B_{12}.

When 50 micrograms of vitamin B_{12} per Kg. of dry matter of the diet were fed, optimum growth rates were obtained. The addition of more vitamin B_{12} concentrate did not result in a further growth response.

Even the highest levels of vitamin B_{12} concentrate fed did not induce completely normal hematopoiesis in 77 days of observation, as indicated by an abnormally high total erythroid percentage in the bone marrow.

Gross symptoms which might be attributed to the deficiency existing in the basal diet were hyper-irritability, posterior incoordination, voice failure, and pain in the rear quarters.

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EFFECT OF VITAMIN B_{12} ON THE GROWING PIG[1,2,3]

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Mc ROBERTS and Hogan (1944), Krider *et al.* (1944), Fairbanks *et al.* (1944), Hogan and Anderson (1948), and Bustad *et al.* (1948) have shown a need for unknown factors or unrecognized vitamins for the growing pig.

In an effort to study a possible source of these unknown factors or unrecognized vitamins, the experiment reported herein was conducted in order (1) to determine whether vitamin B_{12} would increase the growth rate, feed efficiency, and enhance the blood cell counts of pigs fed purified rations, (2) to compare a crude concentrate of vitamin B_{12}, a crude concentrate of animal protein factor, and the pure crystalline vitamin B_{12}, and (3) to compare these findings with those obtained from pigs fed a purified ration to which had been added 10 percent alfalfa and 5 percent fish meal.

Materials and Methods

Five lots of four weanling pigs of mixed breeding, predominantly Hampshire, were used in this experiment. The pigs were distributed equally into lots on the basis of weight, sex and condition. The pigs had been on natural rations previous to the beginning of this experiment.

The purified basal ration used in this experiment was the same as that previously reported by Heinemann *et al.* (1946). The ration consisted of the following percentage composition: casein[4] 26.1, sucrose 57.7, lard 11.0 and mineral mixture[5] 5.2 percent. Water soluble vitamins were fed as follows (in mg. per kg. of live weight daily): thiamine 0.52, riboflavin 0.12, niacin 1.20, pantothenic acid 0.50, pyridoxine 0.20, and choline chloride 10.00. Folic acid was fed at a level of 50 micrograms per 100 grams of feed. Other vitamins were supplied (per pig daily) as follows: vitamin A, 5000 I.U., vitamin D, 500 I.U., vitamin E, 57 mg., vitamin K, (2-Methyl-Naphthoquinone) 2 mg. and vitamin C, 50 mg.

[1] Published as Scientific Paper No 850, Agricultural Experiment Sta tions, Institute of Agricultural Sciences, State College of Washington, Pullman, Washington.

[2] Submitted in partial fulfillment of the requirements for the Ph.D., The State College of Washington.

[3] We are indebted to Dr. D. F. Green and Merck & Co., Rahway, N. J. for supplying the Crystalline Vitamin B_{12}, vitamin B_{12} concentrate and other B-complex vitamins. The cooperation of Dr. T. H. Jukes and Lederle Laboratories, Pearl River, N. Y., in supplying the Animal Protein Factor Concentrate and the Folic Acid is gratefully acknowledged. The Vitamin A & D oil (Oladal) was supplied through the courtesy of Dr. E. B. Carter, Abbott Research Laboratories, North Chicago, Ill.

[4] Vitamin Test Casein GBI, manufactured by General Biochemicals, Inc., Chagrin Falls, Ohio.

[5] Same as used by Wintrobe (1939), and as modified by Heinemann *et al.* (1946).

The pigs in Lot I received the basal ration plus the vitamins listed above (table 1). The pigs in Lot II received the ration fed to the pigs in Lot I plus a vitamin B_{12} concentrate fed at a level to furnish 30 micrograms of vitamin B_{12} per kilogram of feed. The pigs in Lot III received the basal ration plus crystalline vitamin B_{12} injected at a level of 12 micrograms per pig per week. On Lot IV the pigs were fed the basal ration containing one percent of an "animal protein factor" concentrate. The pigs in Lot V received the basal ration plus 10 percent alfalfa meal and 5 percent fish meal, the casein level being adjusted so that the protein content of the ration was the same as that of the basal ration.

TABLE 1. WEIGHT, FEED AND BLOOD ANALYSIS OF PIGS ON VITAMIN B_{12} EXPERIMENT

Lot ration	I Basal	II Basal+B_{12} concentrate	III Basal+B_{12} injected	IV Basal+animal protein factor	V Basal+10% alfalfa and 5% fish meal
No. of Pigs	4	4	4	4	4
No. of Days on Trial	69	69	69	69	69
Av. Initial Wt.	30	30	29	29	26[1]
s[2]	3.5	1.3	3.4	4.2	6.5
Av. Daily Gain[3]	1.1	1.0	1.0	1.1	1.0
s	0.05	0.04	0.04	0.09	0.11
Av. Daily Feed Consumption	1.76	1.75	1.73	1.76	1.73
s	0.01	0.02	0.06	0.01	0.07
Lbs. of Feed per Lb. Gain	1.66	1.77	1.70	1.70	1.72
Av. Hemoglobin[4] per 100 ml. blood	11.4	12.5	12.8	12.3	12.3
s	1.8	0.9	0.5	0.5	0.9
Av. R.B.C. (Millions)[5]	9.29	7.95	8.51	8.32	8.02
s	0.07	0.03	0.50	0.43	0.52
Av. W.B.C. (Thousands)[6]	17.61	16.00	14.80	17.84	19.85
s	7.96	9.75	1.25	4.12	6.01

[1] One pig had to be substituted during the first week and a small pig was all that was available as a replacement.
[2] s = standard deviation.
[3] The pigs were carried to an average final weight of approximately 100 pounds.
[4] Hemoglobin was determined by the method of Evelyn (1936).
[5] Erythrocytes were counted after diluting with Hayem's Solution.
[6] Leucocytes were counted in two percent acetic acid diluent tinted with gentian violet.

Since the genetic background of the pigs was so variable, they were individually full-fed each day in order to allow full expression of their genetic capabilities. The pigs were fed in individual feeding stalls.

Results and Discussion

The data shown in table 1 indicate no difference between the five lots of pigs on the basis of average daily gain and pounds of feed required per pound of gain.

The average daily gain made by all lots of pigs approximately one pound per day. For pigs the size of these, this is a very satisfactory rate of gain. In this experiment, no benefits in growth are indicated by either of the vitamin B_{12} supplements, the animal protein factor, or the alfalfa and fish meal.

The average hemoglobin levels (shown in table 1) of all lots of pigs were normal.[6] While the average hemoglobin level of Lot I was somewhat lower than for the other lots, it was still within the normal range.

Similar findings are indicated with the red blood cell and white blood cell counts. The variation between lots was quite small and all values were normal. On the whole, the white blood cell counts tended to be a little low.

It is interesting to speculate on the reasons why no growth response was found with the pigs fed the vitamin B_{12} supplements when other workers are able to show a response with the check and the young pig. The pigs used in this trial came from sows which had been fed natural rations and these pigs had nursed their dams until they were nearly eight weeks of age. The pigs had access to natural feeds in the meantime. Perhaps, with this sort of a nutritional background, the pigs had sufficient storage of this factor so that additional supplies gave no further growth response. Findings similar in nature to this were demonstrated by Cunha *et al.* (1948) who reported that the ration fed gilts during growth had an effect on reproduction later in life, in other words, there was a carry over or storage of unknown factors necessary for reproduction.

Another possible reason might be that the purified ration was not entirely free of this factor. While the casein used was alcohol extracted, traces of the vitamin might have remained, since, with the rat, crude casein is a good source of this factor. This was reported by Zucker *et al.* (1948). If the pig had only a very small requirement for this factor for growth, then the purified casein might have supplied enough of this factor.

There also might be intestinal synthesis of the factor. Since Bird *et al.* (1946), Whitson *et al.* (1946), and Groschke *et al.* (1948) have reported that cow manure is a good source of the factor for the chick and since Rubin *et al.*

[6] The cooperation of Dr. D. R. Cordy and Mr. J. F. Bone in obtaining the blood data is greatly appreciated.

(1946) demonstrated the presence of this factor in hen feces, perhaps bacteria in the intestine of the pig are able to synthesize sufficient quantities of this factor to supply his needs for growth.

Summary

Under the conditions of the experiment reported herein, no advantage was shown by adding a vitamin B_{12} concentrate, crystalline vitamin B_{12} (injected), an "animal protein factor" concentrate, or alfalfa and fish meal to a purified basal ration for the growing pig.

No significant differences were found in average daily gain, pounds of feed per pound of gain, hemoglobin levels or red and white blood cell counts between the various lots of pigs in this experiment.

Further research needs to be done on the requirement for this vitamin by the growing pig.

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FISH SOLUBLES AND LIQUID FISH FOR GROWING AND FATTENING SWINE[1]

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HIGH quality protein supplements have long been considered essential in swine rations if good results are to be obtained. One of the most widely used protein supplements for swine feeding is soybean oil meal. Vestal (1942) has shown in practical feeding trials that the quality of protein in soybean oil meal is excellent for hogs. Protein evaluation studies with poultry by Almquist *et al.* (1942) and Heuser *et al.* (1946), and with rats by Jones and Divine (1944) have shown the protein in soybean oil meal to be of high value. Although it is recognized that the quality of the protein of soybean oil meal is high, it is also established that the protein supplements of animal origin contain certain growth factors which seem to be lacking in supplements of plant origin (Cary and Hartman, 1947; Hartman *et al.*, 1949; Beeson and Bloss, 1949).

Included among the animal protein supplements, which contain essential unidentified growth factors, are condensed fish solubles and liquid or semi-solid fish. Fish solubles is produced by condensing the water and body fluids resulting from the hydraulic extraction of oil from fish. Liquid fish is the processed combination of both presscake and presswater obtained after whole fish and/or fish trimmings are cooked and pressed to remove the oil.

Almquist (1941) and Block and Mitchell (1946) present evidence to show that the quality of protein in fish solubles is poor, but Hughes and Ittner (1942), Van Poucke *et al.* (1946), Krider *et al.* (1947), Robison (1947) and Catron *et al.* (1947) have shown that fish solubles exert a special beneficial effect when fed in small amounts to growing-fattening swine. Although very little work with liquid fish has been reported, Catron *et al.* (1947) and Krider *et al.* (1948) have noted a slight beneficial effect in feeding liquid fish to swine.

The experiment reported herein was undertaken to study the effects of

[1] The experimental data for this paper were taken from a thesis submitted by H. B. Geurin to the Graduate School of Purdue University in partial fulfillment of the requirements for the degree of Master of Science.

[2] The authors wish to express their appreciation to the Farm Bureau Milling Co., Hammond, Indiana, for furnishing the fish solubles and liquid fish, and to Ivan Moore and Harry Truax of the Farm Bureau, Inc., of Indianapolis for making the arrangements to secure these products.

[3] Contribution from the Department of Animal Husbandry, Journal Paper No. 411, Purdue University Agricultural Experiment Station, Lafayette, Indiana.

adding fish solubles or liquid fish to a swine ration of plant origin fed in dry lot.

Experimental Procedure

First Trial

Thirty purebred Hampshire pigs were allotted randomly into three lots and stratified on the basis of sex and weight. The ingredient composition of the experimental rations fed is presented in table 1. The corn and the soy-

TABLE 1. COMPONENTS OF EXPERIMENTAL RATIONS[1]

Lot	Ingredient	Percent ingredients at different pig wts. (lb.)			
		Initial wt.–65	66–100	101–140	141—market wt.
1	Corn	56.18	68.48	74.78	82.38
	Soybean oil meal	38.70	26.40	20.10	12.50
	Alfalfa meal	5.00	5.00	5.00	5.00
	Vit. A and D oil[2]	0.12	0.12	0.12	0.12
2	Corn	55.98	68.28	74.58	82.18
	Soybean oil meal	37.90	25.60	19.30	11.70
	Fish solubles	1.00	1.00	1.00	1.00
	Alfalfa meal	5.00	5.00	5.00	5.00
	Vit. A and D oil[2]	0.12	0.12	0.12	0.12
3	Corn	55.68	68.08	74.28	81.88
	Soybean oil meal	37.20	24.80	18.60	11.00
	Fish solubles	2.00	2.00	2.00	2.00
	Alfalfa meal	5.00	5.00	5.00	5.00
	Vit. A and D oi[2]	0.12	0.12	0.12	0.12

[1] Mineral mixture fed free choice was composed of 40% steamed bone meal, 40% ground limestone, and 20% iodized salt.

[2] Fortified cod liver oil (Nopco XX) guaranteed to contain 3000 units of vitamin A and 400 units of vitamin D per gram.

bean oil meal content of the rations were changed as the pigs grew in order to maintain the protein at the level recommended by the National Research Council (1944).

The fish solubles and liquid fish were supplied in a premix with 80 percent of soybean oil meal. The manufacturers reported an average analysis of the fish solubles as 50.0 percent water, 31.1 percent protein, 10.3 percent fat, and 0.2 percent fiber; the liquid fish contained 51.0 percent water, 32.2 percent protein, and the following vitamins in milligrams per pound: riboflavin, 4.3, thiamine, 1.6, niacin, 27.0, pantothenic acid, 0.9, and choline hydrochloride, 808.0.

The rations, with the exception of the minerals which were fed separately, were mixed and fed in self feeders. The pigs were kept in adjoining indoor pens with free access to outdoor concrete pens.

Live weights of the pigs were taken at 14-day intervals throughout the experiment. The final growth data were treated statistically by analysis of variance as outlined by Snedecor (1946).

Second Trial

The second experiment was a summer feeding trial which duplicated the winter feeding trial in experimental design and rations fed, except that a fourth lot of pigs receiving two percent of liquid fish was added to the experiment.

Forty uniform Duroc pigs obtained from the Purdue Experimental Swine Farm were used in this trial. One pig from each of lots 1 and 3 was removed from the experiment after six weeks because of ruptures.

TABLE 2. RESULTS OF ADDING FISH SOLUBLES TO A BASAL RATION OF PLANT ORIGIN FOR SWINE (FALL 1947)

Items	Lot numbers and treatments		
	I Basal Ration	II Basal+1% fish solubles	III Basal+2% fish solubles
No. of pigs	10	10	10
Av. initial wt., lbs.	51	51	52
Av. final wt., lbs.	196	222	233
Av. gain per pig, lbs.[1]	145	171	182
Av. daily gain, lbs.	1.03	1.22	1.30
Av. daily feed, lbs.	5.20	5.01	5.22
Av. daily mineral intake, lbs.	0.10	0.04	0.03
Feed per cwt. gain, lbs.	503	410	403

[1] Least significant difference for P = 5% and 1% respectively was 20.6 lbs. and 27.7 lbs.

Results and Discussion

The results obtained in the first trial are summarized in table 2. The pigs in lot 1, fed the basal ration as presented in table 1, made a daily gain of 1.03 pounds and required a total of 503 pounds of feed per 100 pounds of gain.

The addition of one percent of condensed fish solubles to the basal ration increased the average daily gain to 1.22 pounds and greatly improved the economy of gain. The pigs in lot 2 receiving the one percent of fish solubles were 26 pounds heavier at the end of the experiment and required 18.2 per-

cent less feed per unit of gain than the pigs in lot 1. The difference in rate of gain is significant at the five percent level.

When the basal ration was supplemented with fish solubles at the rate of two percent of the entire ration, the pigs gained 0.3 pounds more per day, and there was a saving of 100 pounds of feed for each 100 pounds of gain or approximately a 20 percent improvement in economy of gain. While the increase in growth rate of the pigs receiving two percent of fish solubles is highly significant when compared with the pigs in lot 1, the difference in growth rate between the one percent and two percent fish soluble lots is not statistically significant.

In the second trial, a fourth lot was added to the experimental set-up so that liquid or semi-solid fish might be compared with fish solubles as a supplement to the basal ration. The results obtained in this second trial are reported in table 3. As in the first trial, the pigs on the all-plant ration in lot 1 gained very slowly in comparison to the pigs that were fed the supplemented rations.

In agreement with the results of the first trial, the addition of either one or two percent of fish solubles to the basal ration resulted in highly significant increases in rate of gain and improved the efficiency of feed utilization. Lot 2 pigs gained 35 pounds more per pig on 6.8 percent less feed per pound of gain. They gained 0.3 pounds more per day with a saving of 28 pounds of feed per 100 pounds of gain.

The pigs receiving two percent of fish solubles in lot 3 gained 0.48 pounds more per day than the pigs on the basal ration and required 9.2 percent less feed per unit of gain.

The addition of two percent of liquid fish to the basal ration brought about a significant increase in rate of gain. The lot 4 pigs gained 30.6 percent faster than the pigs in lot 1, or an average of 0.34 pounds more per pig per day. The pigs that received liquid fish consumed 1.2 pounds more feed per day and produced 100 pounds of gain with 13 pounds less feed than did the pigs in lot 1. Catron *et al.* (1947) and Krider *et al.* (1948) have also reported that semi-solid fish improved pig gains slightly when added to a ration of vegetable origin.

When fish solubles and liquid fish are compared for their supplemental value to the basal ration fed the pigs in lot 1, it is apparent in this trial that fish solubles was superior to liquid fish. At the two percent level of feeding, the pigs receiving fish solubles were 19 pounds heavier at the end of the experiment and were 6.3 percent more efficient in feed utilization. When only half as much fish solubles as liquid fish was fed, the results were about the same. Catron *et al.* (1947) have stated that fish solubles was slightly superior to liquid fish in stimulating swine growth.

In both trials reported herein, the pigs on the all-plant ration with soybean oil meal supplying most of the protein made unsatisfactory growth. These low gains are in agreement with the work of Ferrin (1946) and Robison (1947) who likewise found that hogs made poor gains when fed rations similar to the basal used in this experiment. Since there is consider-

TABLE 3. RESULTS OF ADDING FISH SOLUBLES OR LIQUID FISH TO A BASAL RATION OF PLANT ORIGIN FOR SWINE (SUMMER 1948)

Items	Lot numbers and treatments			
	I Basal Ration	II Basal+1% fish solubles	III Basal+2% fish solubles	IV Basal+2% Liquid Fish
No. of pigs	10[1]	10	10[1]	10
Av. initial wt., lbs.	45	45	45	45
Av. final wt., lbs.	169	204	227	208
Av. gain per pig, lbs.[2]	124	159	182	163
Av. daily gain, lbs.	1.11	1.41	1.59	1.45
Av. daily feed, lbs.	4.56	5.40	5.93	5.76
Av. daily mineral intake, lbs.	0.11	0.07	0.08	0.08
Feed per cwt. gain, lbs.	410	382	372	397

[1] One ruptured pig removed after six weeks.

[2] Least significant difference between lots of 10 and 9 pigs for P = 5% and 1% respectively was 15.6 lbs. and 20.1 lbs.

able evidence (Vestal 1942, Almquist *et al.* 1942, and Block and Mitchell 1946) which indicates that soybean oil meal protein is excellent in its quality and well-balanced with regard to amino acid composition, it would seem that the poor growth obtained in this experiment is due to some deficiency other than protein. The fact that only a half percent of dry matter in the form of condensed fish solubles added to the plant ration brought about a significant increase in growth rate suggests a vitamin-like deficiency rather than a protein or amino acid deficiency.

Hughes and Ittner (1942) and Robison (1947) and others have also shown that fish solubles fed in small amounts will stimulate growth rate in swine. Very recently, work with poultry has been reported which throws additional light on the growth stimulating components of fish solubles. Robblee *et al.* (1948) reported on some of the properties of the factor in fish solubles, while Nichol *et al.* (1949) have reported that the newly isolated pure vitamin B_{12} can replace the animal protein factor activity of fish solubles.

Beeson and Bloss (1949) have reported that an APF concentrate (Merck) greatly stimulated growth in swine that were fed a ration of vegetable origin.

Hogan and Anderson (1949) and Johnson and Neuman (1949) have shown that crystalline vitamin B_{12} causes an increase in the growth of baby pigs that have been fed a purified ration.

Evidence has also been reported recently which indicates that vitamin B_{12} does not possess all of the growth stimulating properies of APF or at least that there are other growth factors besides vitamin B_{12}. Bosshardt *et al.* (1949) report that the growth response of mice to vitamin B_{12} is not as great as was obtained with crude liver. Stokstad *et al.* (1949) present evidence to show that there is an auxiliary growth factor in *streptomyces aureofaciens* fermentation products that stimulates greater chick growth than either the maximum dose of crystalline vitamin B_{12} or liver extract.

Summary

Fish solubles and liquid fish have been compared for their supplemental value to an all-plant basal ration of corn, soybean oil meal, sun-cured alfalfa meal, and minerals for growing and fattening swine in dry lot. Two trials were conducted in which the basal ration was 1. Fed alone, 2. Supplemented with one percent fish solubles, or 3. Supplemented with two percent fish solubles. In the second trial a fourth lot was added in which the basal ration was supplemented with two percent liquid fish.

In both feeding trials the results showed that the basal ration was deficient as measured by growth rate and feed required per unit of gain. Fish solubles, at the low levels fed, definitely supplied nutritive factors which improved the basal ration for pigs fed in dry lot in this experiment. The two percent level of fish solubles gave a considerably greater increase in growth than one percent.

In the second trial, the pigs receiving two percent of fish solubles showed a significantly greater growth response than did the pigs receiving two percent of liquid fish. Two percent of liquid fish was equal to about one percent of fish solubles.

The results obtained indicate that condensed fish solubles and liquid or semi-solid fish contain dietary factors other than protein, which greatly improve the nutritive value of a corn-soybean meal ration for growing-fattening pigs.

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FISH, DISTILLERY AND FERMENTATION BY-PRODUCTS STUDIED IN DRYLOT RATIONS OF WEANLING PIGS[1]

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THE responses of weanling pigs to certain water-soluble vitamin supplements were more consistent and apparently greater when they had been raised since birth in drylot rather than on pasture in the tests reported herein. Weanling pigs raised in drylot since birth and fed in drylot showed improved feed efficiency and gains when various levels of the following vitamin supplements were added to the basal rations: dehydrated alfalfa meal, condensed sardine or menhaden fish solubles, semi-solid Redfish product, dried fermentation solubles and certain combinations of dried corn distillers' solubles with either condensed fish solubles or dehydrated alfalfa meal.

Previous experiments have indicated the value of high quality alfalfa meal and dried corn distillers' solubles as vitamin B-complex supplements in certain rations for growing-fattening pigs fed in drylot (Fairbanks *et al.*, 1944; Krider *et al.*, 1944; Fairbanks *et al.*, 1945). These two products as well as condensed sardine fish solubles and dried fermentation solubles have proved to be effective vitamin supplements for sows fed certain rations in drylot during gestation-lactation (Fairbanks *et al.*, 1945a; Krider *et al.*, 1946, 1946a; Krider *et al.*, 1948). Condensed menhaden fish solubles is a source of unidentified growth factors needed for optimum growth of weanling pigs fed in drylot up to 75 pounds (Dyer *et al.*, 1948).

Experimental Procedure and Results

Experiment 1 (1946–47, winter)

The object of this test was to study the supplementary value of dehydrated alfalfa meal, condensed sardine fish solubles, and certain combinations of dehydrated alfalfa meal, condensed sardine fish solubles, and dried corn distillers' solubles for growing-fattening pigs fed in drylot from weaning to 100 pounds live weight.

The seven lots of fall pigs used in this experiment were raised to weaning

[1] These investigations were supported by the donation of funds and products to the University of Illinois by Central Soya Co., Inc., Decatur, Indiana; Dehydrating Process Co., Boston, Mass.; Philip R. Park, Inc., San Pedro, Calif.; Hiram Walker and Sons, Inc., Peoria, Illinois; and Commercial Solvents Corporation, Terre Haute, Indiana.

[2] Acknowledgment is gratefully made for the assistance of R. F. Van Poucke, formerly Assistant in Animal Science, in the conduct of Experiment 2, and R. H. McDade, Chief Swine Herdsman, and his associates.

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age (56 days) in drylot and had been nursed by sows that had been continuously in drylot as described by Krider *et al.* (1948). Each pig was started on the experiment at weaning time and was fed to a final weight of approximately 100 pounds. During the test period the pigs were self-fed, were bedded with shavings, and were confined on concrete floors at all times. These procedures were followed throughout this series of experiments. The rations fed are given in table 1 and the results are briefly summarized in

TABLE 1. RATIONS FED IN EXPERIMENT 1 (DRYLOT)

Lot and ration no.	1	2	3	4	5	6	7
Ingredients	pounds or percent						
Ground yellow corn	67.0	64.0	59.5	61.5	65.0	66.0	63.5
Meat scraps (55% protein)	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Soybean meal, expeller	25.5	24.5	23.0	21.0	23.5	24.5	21.0
Alfalfa meal, dehydrated[1]	—	4.0	10.0	4.0	—	—	—
Condensed sardine fish solubles[2]	—	—	—	—	4.0	2.0	2.0
Dried corn distillers' solubles (27% protein)	—	—	—	6.0	—	—	6.0
Ground limestone	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Iodized salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Fortified vitamin A & D oil	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Crude protein, % (by analyses)	20.3	20.3	19.9	20.0	20.6	20.5	20.2

(½ pound of manganese sulfate was added per 1,000 pounds of mixture)

[1] Alfalfa meal used 10-29-46 to 12-3-46 contained 11.94% crude protein, 27.08% fiber, 57.2 mg. carotene and 4.31 mg. riboflavin per pound of meal. Alfalfa used 12-3-46 to end of test (2-27-47) contained 19.44% crude protein, 20.12% fiber, 82.6 mg. carotene and 8.49 mg riboflavin per pound.

[2] Condensed sardine fish solubles contained 51.96% moisture, 30.98% crude protein, 5.40 mg. riboflavin and 128.48 mg. niacin per pound.

table 2. The data in this test and in subsequent experiments were analyzed statistically using the t-test for unpaired differences (Snedecor, 1946).

The data in table 2 supplemented with observations made during the test seem to justify the following statements.

The basal ration was not adequate and produced a slower rate of gain and less economical gains than the supplemented rations.

Pigs fed 4% dehydrated alfalfa meal (Lot 2) to supplement the basal ration grew more rapidly and required 13% less feed to produce 100 pounds of gain than those fed the basal ration (Lot 1). When the basal ration plus 10% dehydrated alfalfa meal (Lot 3) was fed, the pigs required 81% (306 pounds) as much feed to produce 100 pounds of gain as those fed the basal ration (377 pounds). The value of high-quality alfalfa meal as a water-soluble vitamin supplement is clearly indicated.

The addition of 2% fish solubles produced slightly but not significantly more rapid and more economical gains than the addition of 4% of this product. In supplementing the basal ration, 10% alfalfa meal produced results comparable to those obtained when 2% fish solubles was fed.

There was no significant difference in average daily gains made by the various supplemented lots (Lots 2, 3, 4, 5, 6, and 7). Although there were differences in the performance of the pigs between certain lots, the supplemented rations were considered to be nutritionally adequate for weanling pigs fed in drylot as measured by rate of gain and freedom from abnormalities

TABLE 2. RESULTS OF EXPERIMENT 1 (1946–47, WINTER, DRYLOT)

Items compared	Lot numbers and treatments						
	1	2	3	4	5	6	7
	Basal	Basal +4% alfalfa meal	Basal +10% alfalfa meal	Basal +4% alfalfa meal +6% distillers' solubles	Basal +4% fish solubles	Basal +2% fish solubles	Basal +2% fish solubles +6% distillers' solubles
No. of pigs started	6	10[1]	10[1]	10	10	10	10[1]
Av. initial wt., lb.	29	29	30	29	29	29	29
Av. final wt., lb.	93	98	102	97	100	103	98
Av. daily gain, lb.	0.78	0.89	0.94	0.84	0.87	0.93	0.85
Av. daily feed, lb.	2.95	2.82	2.80	2.63	2.86	2.84	2.85
Feed consumed per 100 lb. gain, lb.	377	328	306	323	334	310	340

[1] Three pigs removed from each of these lots.

of feet, gaits, and skin condition. Rougher haircoats were noted on pigs fed 4% alfalfa meal than on pigs fed 10% alfalfa meal.

Experiment 2 (1945–46, winter)

The object of this test was the same as in Experiment 1. The six lots of fall pigs used in this experiment were raised to weaning age (56 days) in drylot and had been nursed by sows that had been continuously in drylot as described by Krider *et al.* (1948). They were started on the experiment at weaning time and were carried to a final weight of approximately 100 pounds. During the test period the pigs were self-fed and were confined to drylot at all times. Supplemental additions were made to the same basal ration that was fed in Experiment 1. The results, briefly presented in table 3, supplemented with observations made during the experiment, indicate the following conclusions.

Although there were differences in the performance of the pigs between certain lots, the rations fed were considered to be nutritionally adequate for growing-fattening pigs in drylot as measured by rate of gain, and freedom from abnormalities of feet, legs, gaits, hair, and skin condition.

TABLE 3. RESULTS OF EXPERIMENT 2 (1945–46, WINTER, DRYLOT)

Items compared	Lot numbers and treatments					
	1	2	3	4	5	6
	Basal+10% alfalfa meal[1]	Basal+4% fish solubles[2]	Basal+6% alfalfa meal+4% fish solubles	Basal+4% fish solubles+6% distillers' solubles[3]	Basal+4% alfalfa meal+6% distillers' solubles	Basal+4% alfalfa meal+6% distillers' solubles +3% fish meal
Crude protein, % (by analyses)	20.7	20.2	20.3	19.9	20.0	19.8
Riboflavin, mg. per lb. (by assay)	2.45	1.82	2.22	2.27	2.09	2.50
Pantothenic acid, mg. per lb. (by assay)	4.2	3.6	4.4	3.6	3.8	3.3
No. of pigs	10	10	10	10	10	10
Av. initial wt., lb.	36	36	37	36	36	37
Av. final wt., lb.	101	105	104	103	102	101
Av. days to reach final wt.	84	61	62	73	74	72
Av. daily gain, lb.	0.79	1.15*	1.10*	0.93	0.92	0.88
Av. daily feed, lb.	3.08	3.58	3.97	3.09	2.83	2.91
Feed consumed per 100 lb. gain, lb.	400	316	367	341	318	339

* $P \geqq 0.05$, significant over Lots 1, 4, 5 and 6.

[1] Supplied through courtesy of Ralston Purina Co., St. Louis, Missouri. The alfalfa meal contained 19.5% crude protein, 23.8% crude fiber, 104.4 mg. carotene and 6.85 mg. riboflavin per pound.

[2] Supplied through courtesy of Central Soya Co., Inc., Decatur, Indiana. Condensed fish solubles is defined as "the product obtained by condensing the water resulting from the hydraulic extraction of oil from fish." The sardine product contained 49.0% moisture, 31.0% crude protein and 7.65 mg. riboflavin per pound.

[3] Donated by Hiram Walker and Sons, Inc., Peoria, Illinois.

The addition of four percent of condensed sardine fish solubles to the basal ration, alone or in combination with six percent alfalfa meal, produced significantly more rapid gains than rations fed to the other lots ($P \leqq 0.05$).

There was no significant difference between daily gains made by the lot supplemented with alfalfa meal (Lot 1) and the lots receiving the combination of either fish solubles and distillers' solubles, (Lot 4) or alfalfa meal and distillers' solubles (Lot 5), or alfalfa meal, distillers' solubles and fish meal (Lot 6). The 10% level of dehydrated alfalfa meal (Lot 1) produced somewhat slower and less efficient gains in this test than in Experiment 1.

The basal ration supplemented with a combination of six percent alfalfa meal and four percent condensed sardine fish solubles proved to be ex-

tremely palatable as indicated by average daily feed consumption, but was less efficient than four percent fish solubles alone.

Pigs receiving the combination of 4% alfalfa meal and 6% distillers' solubles made 100 pounds of gain on 318 pounds of feed. In Experiment 1, pigs fed this combination required 323 pounds of feed per hundredweight of gain.

Experiment 3 (1947, summer)

The purpose was to test further the supplementary value of 2% condensed menhaden fish solubles, 2 or 4% semi-solid Redfish, and a combination of either 1% or 0.5% condensed menhaden fish solubles with 4% dried corn distillers' solubles. In addition, the effect of adding 0.5 mg. riboflavin per pound of ration was studied. The supplementary riboflavin was added by dried fermentation solubles.

This test consisted of seven lots of late-farrowed spring pigs that were raised by gilts and sows fed a ration composed of 72% ground yellow corn, 14% dehydrated alfalfa meal, 8% tankage, 4% soybean meal, 0.8% limestone, 0.8% steamed bone meal and 0.4% iodized salt in drylot for about 7 to 10 days before and during lactation. They also had been fed an excellent ration during gestation. The amount of the ration fed during lactation was limited so that the pigs would be thrifty but not very heavy at the time of weaning. Lighter weight pigs were considered to be more desirable than heavier ones as "assay" animal for measuring the value of the supplements.

During the experiment the pigs were accorded the same treatment as was given to animals in the preceding tests.

The basal ration fed was the same one used in Experiment 1, except that 0.5% salt with trace minerals was fed, 50% protein meat and bone scraps replaced the 55% protein meat scraps, and it contained one pound less of corn and one pound more of soybean meal per 100 pounds of ration.

The dried corn distillers' solubles contained 7.1% moisture, 26.5% protein, 3.4% fat, 2.3% fiber and 5.68 mg. riboflavin per pound.

The semi-solid Redfish product contained 48.5% moisture, 30.6% protein, 1.18 mg. riboflavin and 18.61 mg. niacin per pound.

By analyses, the condensed menhaden fish solubles contained 48.4% moisture, 33.0% protein, 3.9% fat and 4.50 mg. riboflavin per pound.

The riboflavin content of the dried fermentation solubles was 3630 mg. per pound.

The results of the test are presented in table 4.

The basal ration was inadequate as measured by growth rate and feed efficiency (table 4). As a group the pigs in the basal lot showed the poorest condition, most abnormal gaits, feet and legs, and roughest haircoats of any

group of pigs on test. Some pigs showed incoordinated gaits, goose stepping, and slightly sickled hocks.

The addition of 2% condensed menhaden fish solubles increased daily gains, but not significantly, and improved feed efficiency slightly. These pigs were not entirely normal in feet, legs, gaits and thrift. However, they were superior to pigs in Lots 1 and 3, being especially sleeker and more

TABLE 4. RESULTS OF EXPERIMENT 3 (1947, SUMMER, DRYLOT)

Items compared	Lot numbers and treatments						
	1	2	3	4	5	6	7
	Basal[1]	Basal +2% menhaden fish solubles	Basal +2% semisolid Redfish product[1]	Basal +4% semisolid Redfish product[1]	Basal +4% distillers' solubles +1% menhaden fish solubles	Basal +4% distillers' solubles +½% menhaden fish solubles	Basal +0.50 mg. riboflavin per lb. (from dried fermentation solubles)
Protein, % (by analyses)	20.2	20.1	19.9	—	19.7	19.9	20.8
Riboflavin, mg./lb. (by assay)	1.22	1.16	1.16	1.14	1.83	1.72	1.86
No. of pigs started	10	10	10	10[2]	10	10[2]	10
Av. initial wt., lb.[3]	26.1	26.1	26.2	26.9	25.9	26.8	26.3
Av. final wt., lb.	92.2	92.3	90.6	91.9	93.9	94.1	95.5
Av. days to reach final wt.	81.6	78.7	75.5	66.1	63.2	64.8	65.1
Av. daily gain, lb.	0.82	0.87	0.86	0.98	1.09	1.05	1.06
Av. daily feed, lb.	2.54	2.55	2.54	2.70	3.02	3.09	3.06
Feed consumed per 100 lb. gain, lb.	313	303	298	275	281	297	288

[1] Semi-solid fish product is defined as "the product resulting from the hydrolysis of undecomposed fish and/or fish trimmings from which oil may or may not have been removed and containing a minimum of 40% solids.

[2] One pig removed from lot.

[3] For pigs that finished.

uniform. This level of this fish solubles appeared to be inadequate for optimum growth and freedom from abnormalities.

Although pigs receiving 2% semi-solid Redfish product (Lot3) gained practically as rapidly as those receiving 2% fish solubles (Lot 2), they were not as sleek, thrifty and normal in feet, legs, gaits and haircoats.

Pigs receiving 4% semi-solid Redfish product were superior to those in Lots 1, 2, and 3 in all respects, but were not equal to those in Lots 5, 6, and 7 in condition, uniformity and haircoats. However, the differences in rate of gain between Lots 1, 2, 3, and 4 were not statistically significant.

The combination of 1% fish solubles and 4% distillers' solubles produced daily gains that were highly significant ($P \leqq 0.01$) over those made by pigs in Lot 1 and that were significant ($P \leqq 0.05$) over those made by pigs

in Lots 2 and 3. When 0.5% fish solubles was fed with 4% distillers' solubles (Lot 6) the daily gains were significant ($P \leqq 0.05$) over Lot 1, but not significant over Lot 2 and Lot 3. This indicates that the combination of 1% fish solubles plus 4% distillers' solubles was more nearly optimum than the other combination of these products.

When 0.5 mg. riboflavin from dried fermentation solubles was added per pound of basal ration, the daily gains were very significantly improved ($P \leqq 0.01$) over Lot 1, and were significantly increased over Lots 2 and 3 ($P \leqq 0.05$). Feed efficiency was also improved. It appears that the riboflavin levels in Lots 1, 2, 3, and 4 were inadequate for optimum growth.

Much of the improvement in growth rate in Lots 5 and 6 over Lot 2 can be attributed to the additional riboflavin supplied by the distillers' solubles. This test, however, does not exclude the possibility that the small amount of dried fermentation solubles or the combinations of 1% or ½% fish solubles plus 4% distillers' solubles may have supplied unidentified growth factors needed by the young pigs.

In a previous investigation (Krider *et al.*, 1949) it was shown that weanling pigs fed in the drylot need a practical minimum level of 1.4 mg. riboflavin per pound of ration, and that the only measurable contribution of dried fermentation solubles at the levels fed was its riboflavin content.

Further studies are needed to determine the supplementary value of various combinations of ingredients such as fish solubles and fermentation solubles for weanling pigs fed in drylot.

Experiment 4 (1947–48, winter)

The purpose was to test the supplementary value of 2% condensed menhaden fish solubles and two levels (2% and 4%) of semi-solid Redfish product for growing-fattening fall pigs in drylot.

The four lots of fall pigs were raised to weaning on blue-grass pasture by sows fed an adequate ration. After being weaned at 56 days of age, the pigs were confined to the drylot on concrete floors. Until they were started on test at an average age of 82 days, they were self-fed a ration composed of 72.5% ground yellow corn, 10% meat scraps, 9.5% soybean meal, 7.5% dehydrated alfalfa leaf meal and 0.5% iodized salt.

The basal ration fed was the same as the one fed in Experiment 1, except that it contained one pound less of corn and one pound more of soybean meal per 100 pounds of ration. By analysis and assay the basal ration contained 12.0% moisture, 21.3% crude protein, 1.50 mg. riboflavin, 11.26 mg. niacin and 3.95 mg. pantothenic acid per pound.

The semi-solid Redfish product fed to Lots 3 and 4 contained 48.8% moisture, 30.5% protein, 1.75 mg. riboflavin and 16.8 mg. niacin per pound.

The sample of condensed menhaden fish solubles fed to Lot 2 contained 49.6% moisture, 27.9% protein, 4.22 mg. riboflavin and 107.1 mg. niacin per pound.

No significant differences were obtained between any two of the four treatments. These results (table 5) illustrate the importance of the residual effect of good previous nutrition. Apparently the stores that the pigs had built up from consuming the pre-experimental rations, plus the nutrients in the basal ration, enabled the pigs in Lot 1 to grow at a normal rate very

TABLE 5. RESULTS OF EXPERIMENT 4 (1947–48, WINTER, DRYLOT)

Items compared	Lot numbers and treatments			
	1	2	3	4
	Basal	Basal+2% condensed fish solubles	Basal+2% semi-solid Redfish product	Basal+4% semi-solid Redfish product
No. of pigs started[1]	10	10	10	10
Av. initial age, days	84	84	80	82
Av. initial wt., lb.[1]	37.7	39.7	40.6	39.3
Av. final wt., lb.	96.1	100.6	100.6	101.2
Av. daily gain, lb.	1.20	1.16	1.23	1.20
Av. daily feed, lb.	3.18	3.39	3.24	3.39
Feed consumed per 100 lb. gain, lb.	285	300	279	287

[1] Only 9 pigs finished in each lot.

economically. In Experiments 1 and 3 in which drylot pigs were used, this basal ration was inadequate.

Experiment 5 (1947, summer)

The objectives were: (1) to study and compare the supplementary value of semi-solid fish product from Cod and Haddock and from Redfish with sardine condensed fish solubles; and (2) to compare two levels of semi-solid fish product from cod and haddock for weanling pigs fed to 75 pounds live weight in drylot.

The study consisted of five lots of late-farrowed spring pigs that had been self-fed shelled corn and supplement on rye pasture with their dams until weaned at 56 days of age. Each pig was removed from the test on the weight day that its weight most closely approximated 75 pounds.

All lots of pigs were housed in comparable concrete pens, bedded with shavings, and self-fed the rations given in table 6.

TABLE 6. COMPOSITION OF THE RATIONS FED IN EXPERIMENT 5 (ALL PIGS SELF-FED IN DRYLOT)

Lot and ration no.	1	2	3	4	5
Ingredients	pounds or percent				
Ground yellow corn	60.0	59.0	59.0	59.0	58.0
Soybean meal, expeller	33.0	31.0	31.0	32.0	30.0
Alfalfa meal, dehydrated[1]	5.0	5.0	5.0	5.0	5.0
Semi-solid fish product[2] (from Cod & Haddock)	—	3.0	—	—	5.0
Semi-solid fish product[3] (from Redfish)	—	—	3.0	—	—
Condensed sardine fish solubles (30.9% protein)	—	—	—	2.0	—
Minerals (Krider *et al.*, 1946)	2.0	2.0	2.0	2.0	2.0
Total	100.0	100.0	100.0	100.0	100.0
(Irradiated yeast[4] added to furnish 180 U.S.P. units of vitamin D per pound of feed.)					
Crude protein, percent (by analyses)	20.6	20.5	20.5	20.9	20.6
Riboflavin, mg. per lb. (by assay)	1.54	1.36	1.45	1.36	2.54

[1] Dehydrated alfalfa meal used from 6-24-47 to 8-7-47 contained 19.44% crude protein, 20.12% fiber, 8.49 mg. riboflavin per lb. and 82.6 mg carotene per lb. Alfalfa meal used from 8-7-47 to 9-2-47 contained 17.9% crude protein 21.6% fiber, 7.35 mg. riboflavin per lb. and 122.1 mg. carotene per lb.

[2] The semi-solid fish product from Cod and Haddock contained 47.35% moisture, 32.1% protein, 2.25% fat, 0.12% fiber, 12.4% ash, 4.07% calcium, 2.08% phosphorus, 2.19 mg. riboflavin and 1090 mg. choline per pound. Cod and Haddock fish are usually gutted at sea.

[3] The semi-solid Redfish product contained 47.1% moisture, 33.0% protein, 3.85% fat, 0.07% fiber, 10.01% ash, 2.38% calcium, 1.88% phosphorus, 2.51 mg. riboflavin and 1303 mg. choline per pound. The Redfish were not gutted at sea.

[4] Supplied by Standard Brands, Inc., New York, N. Y.

TABLE 7. RESULTS OF EXPERIMENT 5 (1947, SUMMER, DRYLOT)

Items compared	Lot numbers and treatments				
	1	2	3	4	5
	Basal	Basal+3% semi-solid fish product from Cod and Haddock	Basal+3% semi-solid fish product from Redfish	Basal+2% condensed sardine fish solubles	Basal+5% semi-solid fish product from Cod and Haddock
No. of pigs	10[1]	10[2]	10	10	10
Av. initial wt., lb.	32	33	33	32	32
Av. final wt., lb.	76	77	78	74	75
Av. daily gain, lb.	0.86	0.91	0.92	0.89	0.88
Av. daily feed, lb.	2.29	2.53	2.35	2.50	2.50
Feed consumed per 100 lbs. gain, lb.	273	283	270	289	293

[1] One pig removed. Pleuropneumonia, helminthiasis, and disturbed mineral metabolism reported on post-mortem examination.

[2] One runty pig removed, not posted.

The results presented in table 7, supplemented with observations made during the test, indicate that all rations produced satisfactory growth rates and efficient gains.

The addition of the semi-solid fish products or condensed sardine fish solubles resulted in a slight increase in average daily feed intake and in a slight, but not statistically significant, increase in average daily gains over the basal lot.

The excellent results obtained by feeding the basal ration may be attributed to the following factors. (1) The 5% dehydrated alfalfa meal was of high quality and supplied the essential vitamins needed to supplement the corn-soybean-meal ration. (2) During the preweaning period these pigs were on rye pasture with their dams. During this period they probably stored enough essential vitamins in their body tissues to enable them to perform very satisfactorily on the basal ration in drylot. (3) The combination of 5% alfalfa meal and the "residual effect" of having previously received the rye pasture enabled the pigs to grow at a normal rate very economically when fed the basal ration under the conditions of this experiment.

It has been shown previously that weanling pigs with a good previous nutritional history made rapid and economical gains in drylot when fed a ration composed of 59.5% ground yellow corn, 33% soybean meal, 5% sun-cured alfalfa meal, 2% minerals and 0.5% fortified vitamin A and D oil, a ration quite similar to the basal ration fed to Lot 1 (Krider *et al.*, 1949a).

Summary and Conclusions

Five drylot tests involving 286 weanling pigs fed to approximately 100 pounds live weight were conducted to study the value of condensed fish solubles, semi-solid Redfish product, semi-solid fish product from Cod and Haddock, Menhaden fish meal, dehydrated alfalfa meal, dried fermentation solubles, and combinations of certain of these products. In three of these tests, the weanling pigs used had been raised in drylot while those used in two tests had been produced by sows on pasture. All rations were equated for crude protein.

The responses of weanling pigs to vitamin supplements were greater and more consistent when they had been raised since birth in drylot rather than on pasture. This indicates that the pigs on pasture until weaned stored vitamins in their body tissues which enabled them to respond satisfactorily on a basal ration that was deficient for pigs that had been in drylot until weaned.

A 20% protein ration composed of ground yellow corn, 6% meat scraps, soybean meal, minerals and fortified A and D oil was inadequate for weanling pigs that had been in drylot since birth. Daily gains, thrift, and feed efficiency were improved by the addition of the following levels of water-

soluble vitamin supplements: either 4 or 10% dehydrated alfalfa meal; either 2 or 4% condensed sardine fish solubles; 2% condensed menhaden fish solubles; 4% dehydrated alfalfa meal plus 6% dried corn distillers' solubles; either 2 or 4% semi-solid Redfish product; 4% dried corn distillers' solubles plus either ½ or 1% condensed menhaden fish solubles; and .50 milligram of riboflavin per pound of ration from dried fermentation solubles. The latter response over the basal group was highly significant indicating that the suboptimum riboflavin level may have been a limiting factor in certain of the rations being tested.

Ten percent dehydrated alfalfa meal in the total ration was more nearly optimum than 4% of this product. Two percent sardine condensed fish solubles compared favorably with 10% dehydrated alfalfa meal or the combination of 6% dried corn distillers' solubles plus 4% dehydrated alfalfa meal. Pigs fed 4% distillers' solubles plus 1% menhaden fish solubles gained significantly more rapidly than those fed 2% condensed menhaden fish solubles or 2% semi-solid Redfish product. Four percent semi-solid Redfish product produced thriftier pigs and slightly but not significantly faster gains than 2% of this product. The improved responses obtained from the various products tested are attributed to their content of water-soluble vitamins.

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CONTAMINATION OF PORK MUSCLE AND FAT IN HOGS TREATED WITH BENZENE HEXACHLORIDE[1]

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THE benzene hexachloride (BHC) treatment described by Muma (1947) for hog mange and lice is popular with many swine growers and it appears to be an effective and economical method for control of these parasites. Hixson and Muma (1947) found that the meat of chickens fed, sprayed, or retained in a house previously sprayed with benzene hexachloride has a distasteful flavor. Harwood (1948) quotes Telford as concluding that much of the objectionable odor in crude benzene hexachloride can be removed by fuel oil extraction. If this is done, the product may be used without harming the quality of poultry flesh. Horton and co-workers (1948), working with laboratory animals, found that the effective insecticidal component of benzene hexachloride, the γ isomer, appears to be sufficiently hazardous to warrant the utmost caution in its use.

Because benzene hexachloride is used extensively by swine growers, it is important to know its effect on pork. This experiment was designed to give information on the possible hazards of treating swine with BHC for the control of external parasites.

Experimental Methods

Seven hogs of predominantly Chester White breeding were used in the trial. Both spray and dust treatments were used in this experiment. The dust treatment consisted of dusting each hog with approximately 2 ounces of benzene hexachloride powder containing 1% γ isomer. The spray treatment consisted of applying approximately 3 quarts of a solution of benzene hexachloride (40 pounds of 6% γ isomer of benzene hexachloride per 100 gallons of water) to each animal. The powder was applied with a hand duster and the solution was applied with a hand pressure sprayer that developed about 40 lbs. pressure.

The 7 hogs were divided into 4 lots, 2 pigs in each of 3 treated lots and 1 in the control lot. The control animal was housed in a building away from the treated animals.

Treatment by lots:

Lot I—The pigs were dusted 3 times during the feeding period, at 3, 4½, and 6 months of age. They were sprayed 10 days before and again 1 day before slaughter.

[1] Published with the approval of the Director of the Wisconsin Agricultural Experiment Station.

Lot II—The same dust treatment that was used in lot I, but not sprayed.
Lot III—Control.
Lot IV—The same dust treatment as lot I and sprayed 10 days before slaughter.

The hogs were slaughtered when they were 7 months of age and weighed approximately 225 pounds.

The carcasses were held for 4 days at a temperature of 33° F. before samples were given to a number of people for checking. Eighteen persons judged fresh cuts of pork taken from the center section of the loin. The skin was removed, but all the fat remained with the chops. Each person examined in random sequence the fat and lean for taste and odor in samples from the 4 lots. The samples were fried in individual pans.

Results and Discussion

Table 1 shows the number of persons detecting contamination in the pork samples.

TABLE 1. ODOR AND TASTE CONTAMINATION

Treatment	No. of samplers	No. of samplers detecting contamination			
		Odor		Taste	
		Fat	Lean	Fat	Lean
Lot I	18	4	2	12	12
Lot II	18	0	0	0	0
Lot III	18	4	2	2	0
Lot IV	18	0	0	1	1

A majority of the tasters detected that something was wrong with the pork from animals in lot I. The following is a summary of observations made by samplers who detected the off-flavor in samples from lot I:

1. Little, if any, odor was identified in the raw lean or fat.
2. Heating the meat caused a medicinal odor (not typically a BHC odor) that persisted in the house for some time after heating.
3. An irritating tongue sensation was noticed after eating the pork.
4. Continued frying reduced the intensity of the off-flavor. Only 1 out of 18 detected contamination in the pork from lot IV and none in that from lot II.

From the above results it is quite evident that hogs should not be sprayed with BHC shortly before they are slaughtered. This is of little importance because farmers are not likely to treat hogs immediately prior to marketing or killing for home use. The meat from hogs that were treated 10 days or more before the time of slaughter was little, if at all, affected by the treatment. The fact that some people discriminated against the meat from the

control animal shows that some human error is injected into this type of experiment. The carcasses were hung in numerical order in the cooler; thus the carcasses from lot II were nearest to the carcasses from lot I.

Although the tasters detected an off-flavor in both the fat and the lean of the lot I animals, it is possible that the lean became contaminated from BHC in the outer fat during cooking. Lard rendered from the fat of these animals was tainted. No observations were made of processed meat.

Summary

Pork from hogs treated with liberal applications of BHC (dust and spray) more than 10 days before slaughtered was not contaminated. However, treating animals immediately prior to slaughter caused an off-flavor in the lean and fat. Treated animals showed no gross symptoms of toxicity.

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RECORD OF PROCEEDINGS OF THE FORTY-FIRST ANNUAL MEETING OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

THE forty-first annual meeting of the American Society of Animal Production was held in the Hotel Sherman in Chicago on November 25 and 26, 1949, and a dinner for the honor guest was held at the Stockyard Inn on November 27. Abstracts of most of the papers presented were published in the November 1949 issue of the JOURNAL OF ANIMAL SCIENCE volume 8, pages 603–647.

PRESIDENT'S ADDRESS

W. G. KAMMLADE

President, American Society of Animal Production

IT is a great pleasure, and a privilege, to welcome to this meeting so many members of the Society. It has been a great privilege to me to have served the Society as its Secretary-Treasurer, as its Vice President, and during the past year, as its President. The membership roster of the Society contains the names of many outstanding workers in the field of animal production and related sciences. Distinction has come to these men because their contributions have provided the knowledge which is the basis of the great industries of livestock and dairy production. The members of this Society have also made great contributions to improvements in the processing and distribution of the many products of our animals and have aided in increasing the usefulness and value of these products for human welfare.

While there are many things yet unknown about animal production, animal physiology, nutrition, and genetics, the progress which has been made has been as outstanding as in any other field of human endeavor. Because this is a fact, we can all take great pride in being members of this Society.

The Society has had a good year. Membership has increased, finances are on a sound basis, the JOURNAL has been especially outstanding in the quality of the articles; and its reception has been enthusiastic, not only in this country but in many other countries. For this reception we are, of course, indebted to the research workers and to the conscientious and careful work of the editor and of the editorial board. Since the JOURNAL is the means whereby workers in other countries become acquainted with the quality of work done in this country, it is particularly gratifying to me to report that the JOURNAL has been so well received. I am happy to express, not only my thanks, but the thanks of the membership to those who have done the work

necessary to make the JOURNAL an outstanding and excellent publication.

The work of the Society has been carried on by a large number of carefully selected and hard-working committees. All of the committees have worked conscientiously, and I am sure that this work will be reflected in the programs which you will listen to here and also in the reports which these committees will make at the business meeting.

Most members of the Society are engaged in teaching, research, or Extension activities. In these three fields measurable results are most easily obtained in research work. This is perhaps the main reason why practically all of the articles appearing in the JOURNAL, and why most of the reports to be given at this session, will deal with research studies. The quality of the research being done in the feed lots, in the animal production laboratories and in the laboratories of nutrition, physiology, genetics, and related sciences has improved greatly during the past decade.

One of the most important problems confronting members of this Society, however, is the further improvement of the research work. Much of the easier work has been done, and the work of the future will require great skill and thorough training. To obtain significant results in the future it will be necessary, too, to eliminate much of the fragmentary character of our research work. Because much of the work is fragmentary and carried on without due consideration to related fields, we do not make as much progress as possible. It is my belief that the most significant results to be obtained in the future, will be through cooperative research which involves the efforts of specialists in more than one field. While Webster's dictionary does not contain the word "companionize," I think the word does describe what is needed in much of our research work. Highly trained specialists must work together as companions. Trained in different fields we all have essentially the same ultimate interest, and we must try to bring together our abilities to make our work of more significance.

I know this is not an original idea, but I think it is particularly significant that such attempts be made in the field of animal production where the processes which we study are not discontinuous and isolated phenomena. While we are studying one process all other processes of the animal body are going on. This fact should be recognized, and I think it indicates that we must think in the other man's field of research, as well as in our own. This does not mean that we will be specialists in all fields, but it does mean that we will take into consideration the knowledge and the facts which are available that relate to the work which we are doing. I think specialization is all right, but I believe it is best when it is built on a broad foundation. The spire, or steeple, on a building is most stable when the building has a firm foundation. There is always a relationship between the foundation and steeple.

Likewise there should always be a relationship between specialization and generalization in our activities.

I think it would benefit many if we would try to make our scientific vocabularies more easily understood by the workers in other subjects. When studying the work of those in another field, highly scientific and complicated language is not easily understood. Those who support research work and to whom the results of research are supposed to be beneficial need to be able to understand what we say. I think that we should not overlook the simplicity of greatness and the greatness of simplicity. We ought not have to apologize for using words which intelligent people cannot understand.

During the years which I have been associated with the Society, the two most frequent complaints, regarding the meetings, have been the extreme technical language employed by some speakers and the reporting of work from which the investigator himself could draw no conclusions. I am sure that it would be a serious mistake to dispense with some discussions of current work merely because it has not yet been completed but no one in our membership should attempt to justify the presentation of a paper merely to "appear" on the program or to gain priority in reporting work in progress and from which no conclusion other than "more work is needed" can be drawn. The time of our members is too valuable for that.

It has at times seemed to me as if those whose duties are primarily teaching have felt that they are not fully appreciated as members of the Society. I would like to dispel this attitude if I can. There is no more significant work than that of teaching. The calibre of our future research workers will be high only if they are well taught. We will have good teachers in the future only if those now in our schools and colleges are well taught. The same is true of future Extension workers. It is also true of those who are expected to benefit from our research work and our other activities. I salute all those who have taught me, and I praise all those who have taught you. In our work as teachers, let us remember the tribute paid to one great teacher when it is said, "For youth he opened the door. To youth he showed the way. With youth he marched on."

I wish, too, to pay tribute to our Extension workers. They are valuable and valued members of this Society. Extension workers are essentially teachers and are engaged in work of facilitating the application of the results of research. Theirs is significant work indeed, for without it, we would not have the abundance with which we are blessed and for which we just yesterday gave thanks.

While there are some who would criticize us for being too efficient in our Extension activities, and who deplore surpluses of some agricultural products, it is important that we remember that the world's need is for more and

more. A billion bushels of corn may be a troublesome surplus but the lack of a billion bushels of corn when it is needed would be a far more troublesome deficit. As workers in research and teaching, I think that we should not overlook the fact that those who support our research and teaching efforts are willing to do so to the extent that they do largely because of the contacts they have had with Extension personnel. These are the people who are largely responsible for showing our farmers and others how they can benefit from the results of research; whether it be so-called practical research, or so-called fundamental research, for which in some cases, at least, no practical use has yet been found.

I wish to thank all of the officers, directors, committee members, and others who have worked to advance our Society during the past year, and I urge all to attend the business meeting of the Society and to participate in the deliberations there and to aid in making it still more significant.

A SUMMARY OF THE MINUTES OF THE FORTY-FIRST BUSINESS MEETING OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

H. M. Briggs, *Secretary*
Oklahoma A. and M. College

THE meeting was called to order in the Louis XVI Room of Hotel Sherman, Chicago, at 2:08 P.M., November 26, 1949, by President Kammlade. Approximately 230 persons attended the business meeting and the luncheon which immediately preceded it, and a total of 633 persons registered at the 1949 meetings.

Minutes of the previous meeting were not read as they were published in the Journal of Animal Science, Vol. 8(1): 147–154. It was moved that they be approved as published and the motion carried. The secretary read a report which showed the domestic membership to be 985 and foreign membership 59. This is an increase of 100 domestic members and a loss of one foreign member. Three circular letters were sent to the membership during the year.

The treasurer's report showed that during the year $1149.50 had been spent from the Morrison Award Fund, leaving a balance of $2391.10. Interest accrued on the Morrison Award Trust Fund as of December 31, 1948, was $325.92. There were receipts totaling $11,551.79 received by the Society against an expenditure of $9678.19, or there was an increase of $1873.60 above operating expenses. A $2220.00 series F bond was purchased, leaving $3423.11 in the General Fund as the tangible cash balance. In addition, the Society had assets of $4144.20 in U. S. Bonds, Series F and $7000 in U. S. Bonds, Series G.

F. N. Andrews, chairman of the Auditing Committee reported that examination of the treasurer's books had shown them to be in order.

The editor of the Journal of Animal Science, L. E. Casida, presented the following report:

"A total of 468 manuscripts had been submitted for consideration for publication in the Journal up through November 15, 1949. Of these, 388 were published in volumes one to eight inclusive.

"Publication during 1949 included 63 papers, the president's address and other Society proceedings of the 1948 meeting, 126 abstracts of papers to be presented at the 1949 annual meeting of the Society, subject and author indexes of volume eight and the usual News and Notes section in each of the four issues of the Journal of Animal Science. The different fields of investigation were represented by the following percentages of the papers in

this volume: nutrition, 53; physiology, 27; breeding, 14; and meats, 6. Most papers dealt wholly with one class of livestock, but a few dealt with two or more. Including these duplications, 46 percent of the papers dealt with swine, 40 with sheep, 27 with cattle and 3 with horses.

"Manuscripts received during the period from November 16, 1948 to November 15, 1949 totaled 72. Of these, 11 were withdrawn or rejected, 27 have been published, 17 are in press to appear in the February, 1950 issue, six others are edited and ready for the printer, nine are in the process of being revised by the authors and two others are being reviewed by the editorial committee. Thus a maximum of 61 acceptable papers became available for publication during the past year and at the same time 63 papers have been published in volume eight of the JOURNAL. Publication is therefore keeping pace with the supply of publishable material.

"The editor wishes to announce that the terms of F. N. Andrews, physiology representative, and J. F. Wilson, wool representative on the Editorial Board will expire December 31, 1949. The Executive Committee has appointed E. P. Reineke and R. H. Burns, respectively to replace them.

"The editor wishes to express his appreciation for the vast amount of help that has been given him during the past year by the Editorial Board. He would like to emphasize also the help given by the contributors, the program committees and the secretary of the Society in furnishing, arranging and assembling the abstract material for the November issue. It was through the combined efforts of all of you that this issue was available on approximately November 1."

The report of the business manager of the JOURNAL OF ANIMAL SCIENCE showed the following numbers of the JOURNAL available:

Volume	*Year*	*Complete volumes*	*Copies of numbers in addition to complete volumes*			
			No. 1	*No. 2*	*No. 3*	*No. 4*
1	1942	0	none	55	64	82
2	1943	59	41	24	0	11
3	1944	0	32	0	1	2
4	1945	0	0	0	0	0
5	1946	1	0	21	28	5
6	1947	0	0	0	3	7
7	1948	56	5	6	13	0
8	1949	0	0	5	92	132

These back numbers are for sale by the Business Manager of the JOURNAL. Single copies are $1.00 in the United States. A complete volume is $3.50. Prices elsewhere quoted on request. In addition, the following copies of the Proceedings of the American Society of Animal Production are available.

Year	No.	Year	No.
1915–16	63	1931	79
1920	11	1932	33
1922	372	1934	52
1923	247	1935	53
1924	0	1936	10
1925–26	66	1937	0
1927	64	1938	6
1928	1	1939	23
1929	46	1940	79
1930	33		

The Instruction Committee gave the following report:

Since teaching is one of the most important functions of agricultural colleges, your Committee on Teaching recommends that the theme for the opening session next year should include a paper or papers outlining a standard curriculum for animal husbandry students. It is understood that no curriculum would be acceptable to all colleges of agriculture; however, we believe a concerted effort should be made to suggest minimum requirements; economics, English, mathematics and basic sciences. Likewise, we think a study should be made to develop minimum requirements for animal husbandry, agronomy, and possibly other technical agriculture courses. We further recommend that your Committee on Teaching confer with a similar committee of the Association of Land Grant Colleges, if such a committee is in existence.

The Investigations Committee reported that after considerable study, a program on Problems, Techniques and Experimental Designs in Animal Investigations had been developed and was to be presented in a special symposium as the final session of the 1949 meetings of the Society.

The Pasture and Range Investigations Committee gave the following report:

Your Committee on Pasture and Range Investigations has nearly completed their part of the "Report on Pasture Investigations Technique." Originally this report was prepared by the joint pasture committees of the American Society of Animal Production, American Dairy Science Association and the American Society of Agronomy. Due to a change in the personnel of the pasture committee of the American Society of Agronomy, only recently has this committee started work on the report. This has delayed final preparation of the manuscript and a few more months will be needed for its completion.

In order to maintain the continuity of this work for your Society we recommend that the present Pasture and Range Investigations Committee be given an opportunity to continue this project until its completion. It is therefore suggested that your committee be continued during the coming year so that matters pertaining to the important subject of Pasture and Range Management can be handled for the Society.

The History of Livestock Committee will be continued for another year.

H. H. Biggar, chairman of the Information Committee reported that 25 selected papers have been made available to the publications of the livestock and meat industry. Fifty-three publications used reports relative to last year's meeting.

The Committee on Necrology presented the names of the members who passed away during the year. Eulogies to the memory of Robert F. Miller, Arthur H. Kuhlman, Walter H. Peters, George Haines, W. E. Sewell and William H. Black are published in this JOURNAL.

Burch Schneider, chairman of the Nutrition Program Committee, "Regretted so many papers had to be submitted as 'Read by Title'." Several suggestions were made.

H. W. Marston, the Society representative to the Division of Biology and Agriculture, National Research Council, gave a report telling of activities of this organization. He has been asked to serve on a committee to prepare a Biological Handbook. No recommendation was made from the floor.

Hugh C. McPhee, Society representative to the Inter-Society Committee on Science Foundation Legislation gave the following report:

The Science Foundation legislation has become so complex because of the number of bills which have been introduced and changes which have been made through amendments that it seems desirable at this time to give a brief summary of the pertinent actions taken since the initiation of the idea.

The history of the Science Foundation legislation begins in November, 1941, when President Roosevelt wrote a letter to Dr. Vannevar Bush, Director of the wartime office of scientific research and development, asking him to prepare a report on a post-war science program. This report was submitted in July 1945, under the title, "Science and the Endless Frontiers." It became the basis for the Science Foundation legislation which is still being considered today.

Two identical Bills S. 1850 and H.R. 6448 were introduced in the 79th Congress. No action was taken until the special session called in September, 1945. At that time hearings were begun on these two bills and S. 1850 was passed in July 1946. H.R. 6448 did not come up for a vote and both bills died with the end of the special session.

In the 80th Congress, 1st session, two new bills, S. 526 and H.R. 4102 were introduced. S. 526 was passed in May and H.R. 4102 was passed soon thereafter. In the handling of H.R. 4102, the text was substituted for that of S. 526. As we all know, S. 526 received a pocket veto by the President.

In the 80th Congress, 2nd session, two new and identical bills, S. 2385 and H.R. 6007 were introduced. S. 2385 was passed in May 1948. H.R. 6007 was reported out of the committee but failed to reach the House floor. Both bills died with the adjournment of the session.

In the 81st Congress there was a considerable increase in activity on the Science Foundation legislation. S. 247, a bill identical with S. 2385 of the previous Congress was introduced and passed. Three groups of new bills were introduced in the House during the 81st Congress. H.R. 12, H.R. 185, H.R. 311, and H.R. 2751 were all identical with H.R. 6007 of the previous Congress. H.R. 1845 and H.R. 2308 were identical with S. 247 of the 81st Congress.

H.R. 359 differed substantially from the other bills relative to organization of the Foundation and to the Patent provisions.

When these bills came up before the Committee on Interstate and Foreign Commerce it was realized that careful consideration must be given to all the details involved in the proposals. In the 4 years of hearings up to that time there had been accumulated some 1200 pages of testimony and some 150 eminent workers had testified. Even with all this accumulation of testimony, the committee further reviewed the legislation in public hearings on March 31, April 1, 4, 5, and 26, 1949. In the light of the additional information obtained during these

hearings the committee undertook to rewrite the Science Foundation bill and there was introduced H.R. 4846 on May 24, 1949. This bill was amended on June 14, 1949, and was reported favorably by the committee and recommended to pass.

On July 18, 1949, another bill, H.R. 5669, was introduced and was referred to the committee on Interstate and Foreign Commerce. This bill differs in a fairly large number of respects from H.R. 4846 and at present is under consideration.

In my opinion the Society has a considerable interest in this proposed legislation, particularly in the Division of Biological Science, the Division of Scientific Personnel and Education, and in the Scholarships and Graduate Fellowships.

It would be advisable to maintain contacts with the legislation and, if passed, with some element of the organization, in order that there would be opportunity for this Society to present its needs to the proper officials. I do not believe that our secretary wishes to be burdened with all the details of the legislation which has been proposed but I have obtained copies of H.R. 4846 and H.R. 5669, together with a copy of the report on H.R. 4846, to be filed with the secretary. The report referred to gives in some detail the history of the development to date and includes the reports of the government departments and agencies on the several national foundation bills which have been considered up to this time by the committee on Interstate and Foreign Commerce.

The following report from Ralph W. Phillips, Society representative to the Proposed International Animal Husbandry Association was read:

An international meeting on animal husbandry held in Zurich, Switzerland on October 8–9, 1947 suggested the formation of an International Animal Husbandry Association composed of continental societies banded together to form a World Federation. A committee was formed to consider the development of a European Association. That committee held a meeting in Milan, Italy, during the period June 28–July 1, 1948, with representatives of Belgium, Denmark, France, Hungary, Italy, The Netherlands, Switzerland and the United Kingdom in attendance. Draft statutes for a proposed European Association for Animal Production were drawn up, and as a result of that committee's meeting and subsequent arrangements, the European Association for Animal Production came into existence at a special meeting held in connection with the Fifth International Congress of Animal Production in Paris on November 7, 1949. This special meeting was in the form of a constituent assembly, at which an agreement setting up the European Association for Animal Production was signed by representatives of organizations from Austria, Belgium, Denmark, France, Germany, Iran, Italy, The Netherlands, Spain and Switzerland. Delegates from Luxembourg, Morocco and Tunis stated that their national organizations adhered in principle to the formation of the Association but made the reservation that membership had to be ratified by their respective governments. The British, Norwegian and Swedish groups also indicated that they agreed with the principles laid down in the Charter and Statutes of the new organization, but that for technical or financial reasons they were not in a position to join at the outset.

It should be pointed out that the workers responsible for developing the Statutes had included a proviso that non-European countries in the Mediterranean area might become associated with the European Association for Animal Production until such time as they might form an organization of their own. The adhering organizations differ somewhat in character from country to country, since in some cases the Ministry of Agriculture signed the Agreement, while in other cases independent organizations of breeders signed as the representative organization from the country concerned.

The Headquarters of the newly formed association will provisionally be in Rome in order to have it near the European Regional Office of the Food and Agriculture Organization of the

United Nations, but offers of sites were received from Switzerland, France, Belgium and Denmark, and the possibility of selecting one of these countries as a permanent site will be discussed at a later date. An Administrative Council provided for in the Constitution will hold its first meeting in December, 1949, to decide upon the Association's program of work and budget for the next year. A proposal was adopted to ask each of the adhering associations to make annual contributions of 3500 Swiss francs. Professor A. M. Leroy was elected President of the Association, and members of the Administrative Council are Signor Sola of Italy, Professor Amschler of Austria, Mr. Bakhoven of The Netherlands, Professor Jespersen of Denmark, Mr. Lievens of Belgium and Dr. Engler of Switzerland. The first three were elected for a six-year term and the latter three for a three-year term each.

A letter from the Ralston Purina Committee was read, which expressed their appreciation for the way the Purina Research Fellowships were handled in 1949.

C. J. Watson of Ottawa, Canada, expressed the interest of the European Society of Animal Production in the American Society of Animal Production and that the former not only sent their best wishes but expressed the hope that our Society not only maintain an interest but lend what assistance we could to theirs.

The following resolutions were presented by the committee and were passed by the Society.

1. To the management of the Hotel Sherman, we express our thanks and appreciation for the excellent rooms and facilities provided for our meetings without cost to the Society.

2. To John Morrell and Company, we are indebted for splendid service rendered in making available at our meetings reprints of the abstracts of papers presented. We are grateful for this interest in the work of the Society.

3. To the officers and members of committees we extend commendation of the first order for the excellent program presented for our consumption and edification at the 1949 meeting of the Society.

The report of the Nomination Committee was published in the November, 1949 issue of the JOURNAL OF ANIMAL SCIENCE. In the election that followed, P. S. Shearer was elected President, E. W. Crampton, Vice-President, and H. M. Briggs re-elected Secretary-Treasurer.

The meeting adjourned at 3:51 P.M.

MEMORIALS

WILLIAM HENRY BLACK

William Henry Black, a veteran of more than 30 years' service in the Animal Husbandry Division of the Bureau of Animal Industry, during most of which time he had been in charge of the Division's extensive beef and dual-purpose cattle investigations, died on July 23, 1949. Mr. Black was actively engaged in his research studies to within a few days of his death. Since March 7, 1949, he had served as the first director of the Bureau's new Front Royal Beef Cattle Research Station at Front Royal, Va., an assignment to which he had transferred at his own request.

Born on a farm near Ft. Dodge, Iowa, on August 30, 1888, and reared on the farm, Mr. Black was graduated from the Iowa State College in 1910 with the degree of Bachelor of Science in animal husbandry. He served as professor of animal husbandry at the Arkansas Agricultural and Mechanical College, Jonesboro, Ark., from 1910–12, following which he spent six years in livestock farming on his home farm. In 1918 he entered the Bureau of Animal Industry as a beef cattle extension specialist in the Bureau's program to increase food supplies for World War I. In 1920 he transferred to the Animal Husbandry Division of the Bureau in Washington where he served until his transfer to the Front Royal Station earlier this year.

Mr. Black's long career with the Bureau of Animal Industry was one of outstanding leadership in the field of beef cattle research, through which he has made substantial contributions of research information of economic value to the livestock industry. His recognition of the problem of a phosphorus deficiency in the range forage of the Gulf Coast Region, and his part in developing methods for correcting the deficiency with cattle produced there is especially noteworthy.

Other outstanding work accomplished under Mr. Black's leadership includes the development of methods for wintering beef cattle; the feeding of grain supplements to fattening cattle on pasture; and pioneer work on the creep-feeding method. He also contributed largely to the development of methods for estimating the breeding values of purebred cattle through performance studies. In 1931 he travelled to South Africa and selected the herd of Africander cattle imported at that time by the King Ranch of Texas.

An able and prolific writer, Mr. Black contributed a heavy volume of material to the literature on beef cattle subjects, including numerous technical and popular bulletins, circulars, leaflets, and Yearbook articles of the Department of Agriculture, and many articles for the leading agricultural periodicals.

Mr. Black is survived by his widow, Mrs. Hazel M. Black, a daughter, Helen Elizabeth (Mrs. Robert Foley) and one grandson.

GEORGE HAINES

Dr. George Haines, Animal Geneticist who had been with the U. S. Department of Agriculture's Office of Experiment Stations for 24 years, died on August 28, 1949, after an illness of several years. He was born in Millbrook, New York, on August 1, 1897.

George Haines went to Cornell University where he obtained his B.S. and M.S. degrees in Animal Husbandry and related subjects. In 1922, he joined the staff of the Office of Experiment Stations, U.S. Department of Agriculture, as Specialist in Animal Husbandry. For some years, he devoted his time to the preparation of abstracts in the fields of animal husbandry and animal genetics for the *Experiment Station Record*. During this period, he worked nights and holidays at the nearby University of Maryland where, under the joint guidance of Dr. Devoe Meade, Head of the Department of Animal Husbandry, and Dr. Sewall Wright, Collaborating Professor, he obtained in 1929 his doctor's degree in the field of animal genetics. His thesis, "A Study of Fertility and Related Conditions in the Guinea Pig," resulted in a series of commendable research papers which brought him recognition as a promising young research worker.

Soon he was promoted to a position of administrative responsibility in the Office of Experiment Stations and for some years, until stricken with illness, he assisted in the review of Federal-grant work at the State Experiment Stations. During this period he travelled widely throughout the country; and his keen, alert mind and high ideals for research became widely recognized and appreciated.

Dr. Haines joined the Masonic Order, and in 1932 was elected Master of Mount Herman Lodge in Hyattsville, Maryland. He was an active member of the Presbyterian Church, a member of the American Society of Animal Production, the Genetics Society of America, and the American Association for the Advancement of Science.

He is survived by his wife, Helena J. Haines, a son, Charles E. Haines, two daughters, Mrs. Caroline Wien, and Miss Helene Haines, and two grandsons.

ARTHUR HENRY KUHLMAN

Dr. Arthur Henry Kuhlman was born January 1, 1886, at Lowell, Wisconsin, a son of Fred and Anna Kuhlman. He died at Stillwater, Oklahoma, on September 26, 1949. Dr. Kuhlman graduated from Juneau, Wisconsin, High School in 1906. He received his B.S. degree in Animal Husbandry from the University of Wisconsin in June, 1910; his Master's degree from the same institution in 1916; and served the University for seven years in the capacities of Assistant and Instructor. During the year 1917–18 he acted as Emergency Demonstration Agent at Juneau, Wisconsin. From 1918–26 he held the position of Associate Professor of Animal Husbandry at South Dakota State College, Brookings, South Dakota. He then returned to the University of Wisconsin for further graduate study and was granted the degree of Doctor of Philosophy in Genetics in June, 1928. In 1929 he became a Professor of Dairying at Oklahoma Agricultural and Mechanical College, which position he held until the time of his death.

Dr. Kuhlman is the author of over sixty scientific publications in the form of bulletins and journal articles. These include several on genetics, but his work dealt very largely with the nutrition of the various classes of livestock, particularly dairy cattle.

At the time of his death, Dr. Kuhlman was a member of Alpha Zeta, Sigma Xi, Phi Sigma, Farmhouse, the American Association for the Advancement of Science, American Society of Animal Production, and American Dairy Science Association. Dr. Kuhlman was also very outstanding in Masonic work.

Dr. Kuhlman made two trips abroad where he attended livestock shows and visited livestock farms in England, Scotland, Ireland, the Channel Islands, Holland, Belgium, Germany, Switzerland, and France.

Dr. Kuhlman was a gentleman who was honored and respected by all who knew him. He played an important part in the life of his community; and his passing is deeply mourned by all who knew him.

ROBERT FREDERICK MILLER

Robert Frederick Miller, Professor of Animal Husbandry, the University of California at Davis, passed away October 7, 1949, in the University of California Hospital in San Francisco.

Professor Miller was born August 20, 1889, in New Ulm, Texas. He was graduated with the Bachelor of Science degree from Texas A. and M. College in 1909 and was granted the M.S. degree from Iowa State College in 1912. His appointment as associate professor of animal husbandry at Montana State College was terminated in 1914 when he accepted an invitation to join the faculty of the University of California. He attained full professorship in 1939.

Professor Miller, one of the leading sheep specialists of America, was often called to officiate as a judge of sheep at the more important livestock exhibitions of the country, including the International Livestock Exposition in Chicago. He was keenly interested in animal nutrition and was an authority on the feeding of sheep on pasture, in the feedlot or on the range. Every production problem of the wool grower of the far West became his immediate concern, and his many publications and monographs in this field are a monument to his life.

He was a member of Alpha Zeta, Sigma Xi, and the American Society of Animal Production. He was past master of Athens Lodge, F. and A.M., Davis. For many years he was President of the Board of Trustees of Davis Elementary Schools.

He is survived by his wife, Roxie Knolle Miller, two daughters, Mrs. Virginia Seyms, Santa Rosa, California, Mrs. Josephine Crum, Winters, California, and a son, Robert Frederick Jr. of Davis.

WALTER H. PETERS

Professor W. H. Peters, Chief of the Animal Husbandry division at the University of Minnesota, passed away on August 8, 1949, at the age of 64. "Chief" as he was affectionately known to his friends, students, and associates received two special honors during the last year of his life. Last winter, at the time of the International Livestock Exposition, his portrait was hung in the world-famous gallery of the Saddle and Sirloin club in Chicago. A few months later, his portrait was also hung in the Master Livestock Breeders' Gallery at University Farm.

Professor Peters was born near Keokuk, Iowa, on July 9, 1885. He attended a one-room school and Keokuk high school. He was graduated with honors from Iowa State College in 1908, and the next year became head of the Department of Animal Husbandry at Manitoba Agricultural College.

In 1914, Professor Peters was named head of the Animal Husbandry section of North Dakota Agricultural College; and four years later he came to the University of Minnesota.

He was livestock editor of *Farm Stock and Home* from 1916 to 1931 and of the *Farmer* for the last 18 years. His book, *Livestock Production*, is now used widely in colleges throughout the nation. Collaborating with G. P. Deyoe, he wrote another book, *Raising Livestock*, in 1946.

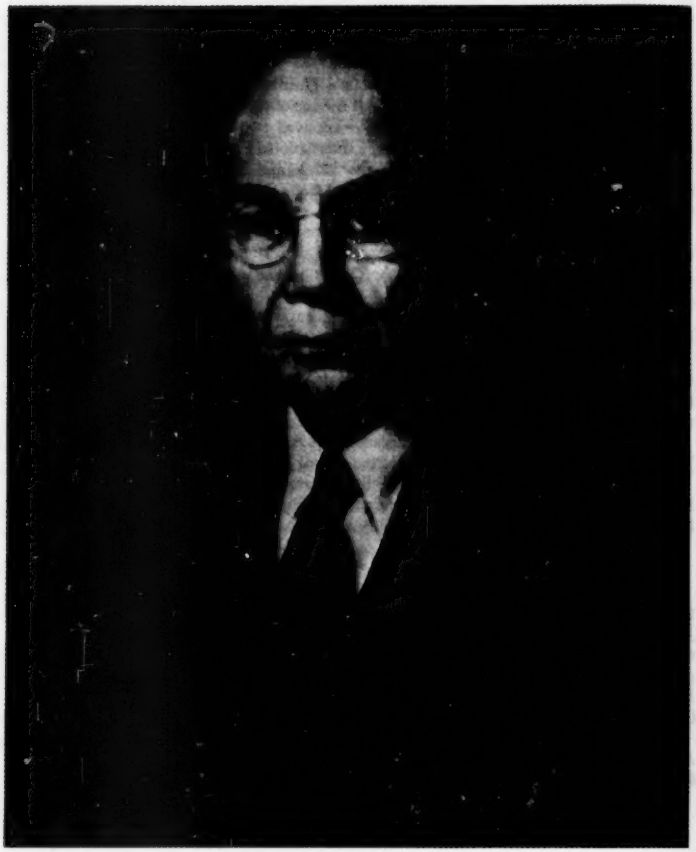
In 1941, Professor Peters served as president of the American Society of Animal Production. The JOURNAL OF ANIMAL SCIENCE was started during his term.

Mr. Peters is survived by Mrs. Millie Gillette Peters, a son Robert G. Peters, a daughter, Mrs. W. E. Remmele, and four grandchildren. His mother, Mrs. Kate Peters, and a sister, Mrs. John Wyatt of Keokuk, Iowa, also survive.

W. E. SEWELL

W. E. Sewell, Head of the Products Service and Nutritional Development Department of the Buckeye Cotton Oil Company, a subsidiary of the Procter and Gamble Company, died on July 21, 1949, in Ivorydale, Ohio. Prior to coming to Buckeye in 1946, he had been a member of the faculty of the Alabama Polytechnic Institute, Auburn, for twenty years. He was a graduate of the same institution, receiving his B.S. degree in 1924. In 1925 he was given the M.S. degree from the University of Missouri. Continuing his graduate work at Iowa State College, he completed his doctorate in June 1943.

Dr. Sewell was a member of the Nutrition Council of the American Feed Manufacturers Association, the American Society of Animal Production, and the American Oil Chemists Society.



JOHN ADDISON HILL

Reproduction of a portrait presented to the Saddle and Sirloin Club in Chicago by the American Society of Animal Production on November 27, 1949. John A. Hill was the Honor Guest of the Society during its annual meeting which was being held at that time.

JOHN ADDISON HILL

Honor Guest—1949

John Addison Hill was born on an Ohio farm in 1880, the eldest of a family of eight children. His parents soon moved to Nebraska and later, back to Ohio. There John worked on the farm and went to a country school. As a young man he returned to the west to work a half section of undeveloped land belonging to his uncle, a civil engineer in Big Horn county, Wyoming.

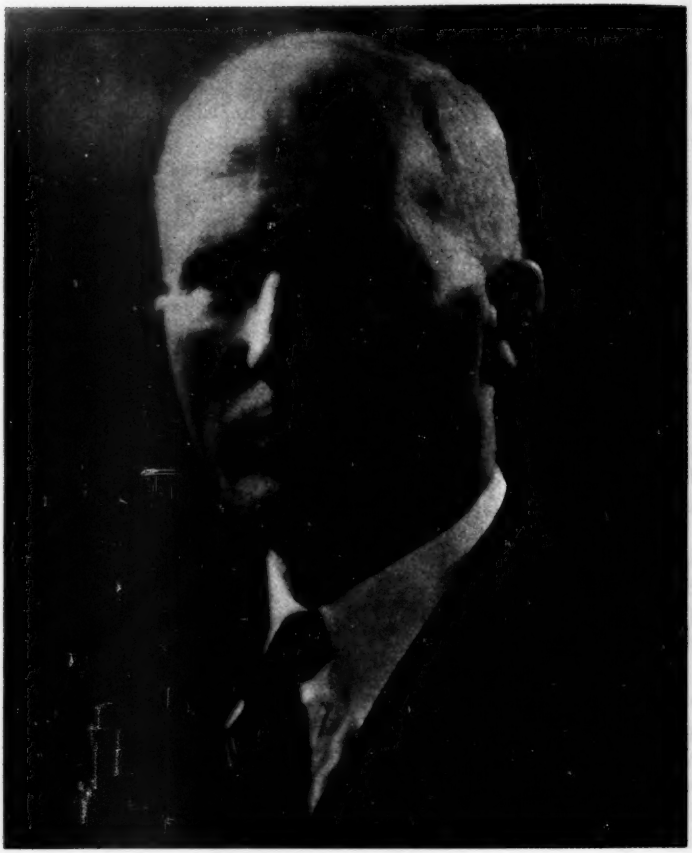
His experiences with farming and with irrigation prompted him to go to college to study agriculture. The University of Wyoming offered the possibilities of what he wanted. During his college years this young man earned all his expenses and carried a fulltime schedule. He impressed his teachers, graduated with distinction and found time to be a member of the University's football team.

Following graduation, he joined the staff of the University of Wyoming and was sent to the Philadelphia textile school for special instruction in wool grading and scouring. His title at the University was Wool Specialist and Professor of Textile Industry, and he now was head of a new department created especially for his abilities.

John A. Hill became Dean of the College of Agriculture and Director of the Agricultural Experiment Station at the University of Wyoming in 1923. Since then he has at times served also as acting president of the University. During all of these years he has in addition taught a course in wool production and marketing.

Dean Hill's service to the wool industry has been outstanding. To him much of the credit is due for a state average increase of three to four pounds per head in wool production and five to tend pounds per head in lamb weight with a proportionate increase in the size of ewes. He has established and maintained at the University a pilot plant for sorting wool. He has done much to establish research for the improvement of wool production through breeding. He has also maintained a sound marketing and counselor service for numerous periodicals. His weekly Wool Letter has been of inestimable value to the wool growers and reflects his marked ability in the use of the English language.

Dean Hill has had keen judgment, clarity of thought and a constant courage to express his own opinions. He has been a successful administrator, an able leader, a wise counselor, an exemplary father and a friend to cherish.



GUSTAV BOHSTEDT

Gustav Bohstedt was awarded the fourth Morrison Award, which was presented to him during the 41st Annual Meeting of the American Society of Animal Production in Chicago on November 26, 1949.

THE MORRISON AWARD

1949

The Morrison Award Committee of the American Society of Animal Production selected Dr. Gustav Bohstedt of the University of Wisconsin to receive the Morrison Award for 1949. Dr. Bohstedt's research has covered a wide range of subjects in the field of applied animal nutrition. Deserving of special mention is his work on the role of minerals and vitamins in the rations of farm animals, studies on the production, storage and feeding value of various silages and dry roughages, critical evaluation of crude fiber as a constituent of farm animal rations and studies on the utilization and value of urea in the ruminant ration. His talent in interpreting research findings in terms of farm and feed lot practice has been outstanding. Literally thousands of livestock producers in all parts of the country have heard him discuss research results and have profited by his suggestions and advice. In addition to his research activities, Dr. Bohstedt has been a stimulating and effective teacher and an able administrator.

Dr. Bohstedt received his B.S. degree in 1915, his M.S. in 1916 and his Ph.D. in 1925, all from the University of Wisconsin. He served as Assistant in Animal Husbandry at Wisconsin 1915–16 and at Iowa State College 1916–17; as Instructor and Assistant Professor of Animal Husbandry at Wisconsin 1917–21; as Chief of the Department of Animal Industry at the Ohio Agricultural Experiment Station 1921–28; as Professor of Animal and Dairy Husbandry at Wisconsin 1928–43; and as Chairman of the Animal Husbandry Department at Wisconsin since 1943.

He served as Secretary of the American Society of Animal Production 1921–23, as Vice President 1923–24, and as President in 1925.

J. L. KRIDER

J. L. Krider was awarded the second American Feed Manufacturers' Association Award, which was presented to him during the 41st Annual Meeting of the American Society of Animal Production in Chicago on November 26, 1949.

THE AMERICAN FEED MANUFACTURERS' ASSOCIATION AWARD

1949

Many activities have had the attention of Dr. J. L. Krider, the recipient of the American Feed Manufacturers' Association Award for 1949. This attention always has been effective and productive, for his life has been marked by many successful achievements. Before he entered upon his professional career he had been an outstanding participant in 4-H Club work and had won one of the National Awards presented annually by Mr. Thos. E. Wilson. His undergraduate college career was marked by participation in many student affairs and culminated in his graduation with highest honors.

He then entered the field of graduate study and received the Doctor of Philosophy degree in 1942 and then returned to Illinois where he has had charge of the work in teaching and research relating particularly to swine. In this responsible position, he has been actively engaged with many others at the University of Illinois and at various other institutions in research in the nutritional, physiological, genetic, health, and disease and general management aspects of swine production. This Award of the American Feed Manufacturers' Association is in recognition of his work in the various phases of feeding and nutrtion. He has given special attention to the value of various feed nutrients in rations for growing-fattening pigs and for breeding gilts and sows. In this field his work has been very productive and his counsel has been widely sought. He is highly respected by both undergraduate and graduate students, as well as by his colleagues on the staff.

CHAIRMEN OF COMMITTEES, PROGRAM CHAIRMEN AND SPECIAL REPRESENTATIVES FOR 1950

Standing Committees

Committee on Investigation ..... C. E. Terrill
Committee on Instruction ..... E. H. Hughes
Committee on Extension ..... George R. Johnson
Committee on Membership ..... E. W. Crampton

Special Committees

Committee on Pasture and Range Investigations ..... G. O. Mott
Committee on History of Livestock ..... C. W. Gay
Committee on Information ..... R. C. Pollock
Committee on Necrology ..... E. F. Ferrin
Nominating Committee ..... Paul Gerlaugh
Committee on Morrison Award ..... E. W. Crampton
Committee on American Feed Manufacturers' Award in Nutrition ..... W. P. Garrigus
Beef Cattle Type Specification Committee ..... J. C. Miller

Program Chairmen

Breeding and Genetics Section ..... H. H. Stonaker
Extension Section ..... George R. Johnson
Meats Section ..... D. C. Brady
Nutrition Section ..... R. H. Grummer
Pasture and Range Section ..... R. M. Forbes
Physiology Section ..... J. F. Sykes
Teaching Section ..... E. H. Hughes

Special Representatives

Inter-Association Council ..... E. A. Livesay
Science Legislation ..... H. C. McPhee
Council of American Association for Advancement of Science ..... F. F. McKenzie
Division of Biology and Agriculture, National Research Council ..... H. W. Marston
Proposed International Animal Husbandry Association ..... R. W. Phillips
Ralston Purina Award Committee ..... W. M. Beeson

NEWS AND NOTES

Applications for the Ralston-Purina research fellowships should be on file by March 1. Application blanks may be obtained from the Ralston-Purina Research Awards Committee in care of Mr. J. D. Sykes, Ralston-Purina Co., St. Louis, Missouri. The fellowships are for $1440 annually and awards will be made in the fields of nutrition and physiology research as applied to dairy, poultry and animal husbandry, and in research in transmissible diseases of livestock and poultry. Individuals qualified for graduate study in any Land-Grant Agriculture College and approved Veterinary Colleges are eligible.

Two appeals that should be of special interest to members of the Society were received by the Secretary following the recent annual meeting; they would have been presented at the meeting had they been received earlier. One appeal came from Milton L. Smith, Director, Educational Unit of CARE and the other from Howard A. Meyerhoff, Administrative Secretary, American Association for the Advancement of Science, with which organization we are associated. Each expressed hope the American Society of Animal Production would take action either as a society or as individual members to assist in rehabilitating the scientific libraries of Europe and Asia and to "repay some of the debt we owe to the wells of learning from which we have drunk so deeply." The officers of the Society are publishing this notice because Society action could not be taken until the annual meeting on November 25, 1950, and immediate response has been urged. Any members who care to make an individual contribution or desire more information should contact Milton L. Smith, CARE, 50 Broad Street, New York 4, N. Y.

Berry N. Duff, extension sheep and wool specialist, Colorado A. and M. College, has resigned to enter commercial work.

James G. Fuller, professor of animal husbandry, University of Wisconsin, was in immediate charge of a group of 67 students from the University of Wisconsin, on the summer training cruise for naval reserve officers in the Pacific from August 2 to September 13.

O. K. Quivey, manager of agricultural development for the B & O railroad for many years and agricultural graduate of Purdue University, died in Baltimore, Maryland, on July 21. L. S. Hartley, a graduate of West Virginia University, has been promoted to the vacancy.

L. C. Madison, extension animal husbandman, Pennsylvania State College, is taking sabbatic leave from October 1 to April 1, during which time he will visit agricultural experiment stations and other places of interest from coast to coast.

William E. Dinusson, with degrees from Oklahoma A. and M., Texas A. and M., and Purdue, has been made associate professor in animal husbandry at North Dakota State College to succeed Burl Winchester, resigned.

J. S. Buchanan, former County Agricultural Agent at Lebanon, Virginia, and V.P.I. graduate, became assistant animal husbandry specialist in the North Carolina Extension Service on October 1, 1949.

James V. Coyner, animal husbandry graduate of Virginia Polytechnic Institute, and recently buyer for an eastern packing company, has been named eastern field representative for the American Aberdeen-Angus Breeders' Association, with headquarters at Warrenton, Va.

Grant W. Sherritt, holding degrees from Iowa State College and the University of Illinois, has been appointed instructor in animal husbandry at Pennsylvania State College and will serve as fieldman in the cooperative swine breeding study now under way between the Pennsylvania State College and the U. S. Bureau of Animal Industry.

Modern Breeds of Livestock by Hilton M. Briggs was published by the Macmillan Company, New York late in 1949. This book was written to acquaint the student and prospective livestock breeder with the past development of the respective breeds of livestock. While history has been stressed, an attempt has been made to evaluate the adaptability of each breed for modern production. The book covers 71 breeds, contains 201 photographs of outstanding animals and is indexed.

Richard T. Clark will fill the position in the Animal Husbandry Division formerly held by W. H. Black who died last July. His headquarters will be at Denver, Colorado, where he will have leadership in planning, reviewing and evaluating research in the Bureau of Animal Industry's beef and dual purpose cattle breeding, feeding and management program at Beltsville, Maryland and at the Bureau Field stations in Montana, Louisiana and Florida and cooperatively at 35 state experiment stations. Dr. Clark was formerly the head of Animal Industry and Range Management at the Montana Agricultural Experiment Station and then with the U. S. Bureau of Animal Industry as animal husbandman engaged in cooperative beef cattle investigations at the Montana station.

Clarence F. Winchester is now Physiologist in charge of research projects relating endocrinology to problems of nutrition in the Animal Husbandry Division, U.S.D.A. Research Center, Beltsville, Maryland. He was formerly Associate Professor of Nutrition at the University of Florida.

A. O. Rhoad of the Inter-American Institute of Agricultural Sciences and L. D. Wilson of the Virginia Polytechnical Institute made a survey of the veterinary and animal husbandry curricula of schools in Latin America during the months of June, July and August. This survey was made under the joint auspices of the Inter-American Institute of Agricultural Sciences and the Rockefeller Foundation.

L. Otis Emik, formerly statistician and geneticist with the United States Sheep Experiment Station and Western Sheep Breeding Laboratory at Dubois, Idaho is now with the Statistical Branch of the United States Public Health Service. He will develop a research program for and be in charge of veterinary statistics dealing with those diseases which affect both man and animals.

W. H. Riddell, Head of the Dairy and Animal Husbandry Department at the University of Vermont recently was honored with the eight point blue and white cross of the Netherlands for service to the country and the royal house. His citation came for his contribution to reconstruction and recovery in the Netherlands and Indonesia.

Howard H. Voelker has been appointed Assistant Professor of Animal Husbandry at the University of Arkansas. He will teach courses in dairy husbandry and assist with research in that field. He holds a B.S. degree from Iowa State College and a M.S. degree from Kansas State College.

Paul E. Howe was a representative of the Bureau of Animal Industry at the International Livestock Congress in Paris, November 3 to 10, 1949.

R. E. Patterson, Assistant Director, Texas Agricultural Experiment Station, was the animal husbandry representative on a recent Food and Agriculture Organization Mission to Nicaragua. This mission was to survey and analyze the agronomy, forestry and livestock needs of that country.

W. V. Lambert, dean and director of agriculture at the University of Nebraska, headed an ECA mission, which spent three months in Africa last fall, in a study of opportunities for research projects on the utilization of the resources in certain parts of that continent to supply food and other needed products.

H. R. Guilbert, of the animal husbandry staff, University of California, recently returned from an extended trip to Continental Europe and Great Britain, where he attended International meetings and conferences and also did some advanced study.

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